KENTUCKY
COMPOSTING MANUAL

Prepared for:

Environmental and Public Protection Cabinet
KY Department of Environmental Protection

Division of Waste Management

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COMPOSTING IN KENTUCKY

Section I - Introduction to Waste Disposal

Some method of waste disposal has been a necessity throughout mankind's existence. However, in earlier ages, because of lower population over the earth's surface, nature was able to recycle mankind's waste, rendering it into reusable material and nutrients for plant growth. With the advent of industrial society and concentration of populations in cities and towns, along with the increased production of paper and packaging materials, mankind has created a solid waste disposal problem. Alternatives and new ideas for solid waste disposal must be considered.

In general, three to five pounds of solid waste are generated nationally per capita per day. In Kentucky, it has been estimated that residential and commercial waste generated is 4.67 pounds per capital per day. A community with a population of 40,000 would generate over 93 tons of waste per day or 34,000 tons per year. Each county in Kentucky has developed a solid waste management plan with the goal of reducing by 25% the amount of solid waste annually going to landfills. Composting is one important means to achieve this goal for waste products (components) that are naturally biodegradable.

A. Waste Definitions

In general "waste" includes (a) Hazardous waste, (b) Special Waste, and (c) Solid Waste. "Special Waste" includes sludge from both water treatment and wastewater treatment facilities. "Solid Waste" includes municipal solid waste and industrial solid waste. "Municipal Solid Waste" includes household and commercial solid waste. Any reference to special waste will refer only to sludge. However, all appropriate definitions are included in the GLOSSARY.

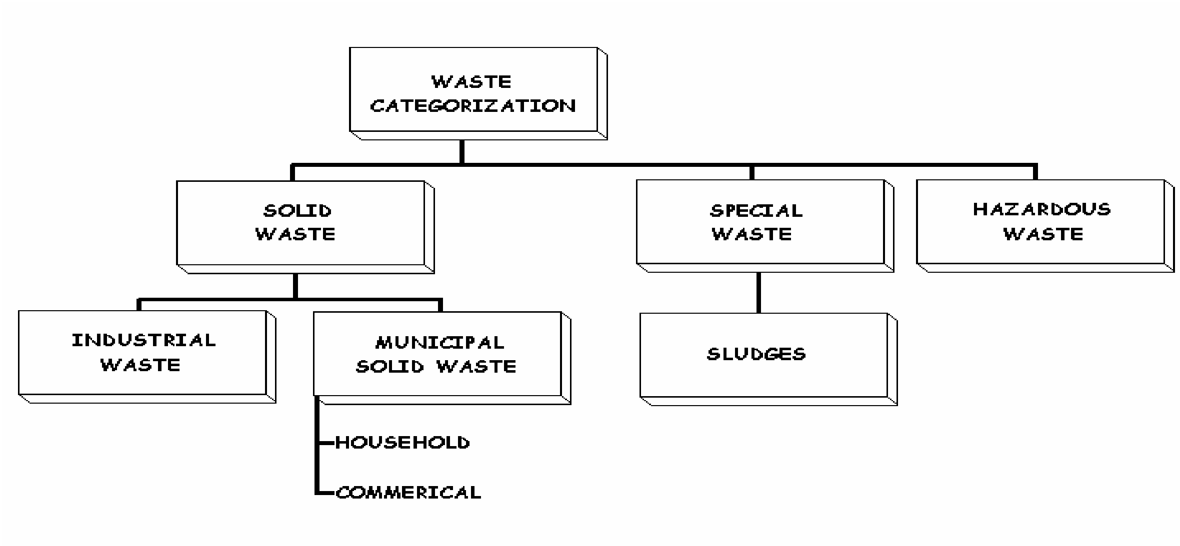

Figure 1-1 Waste Categorization

B. Regulatory Overview

Kentucky Revised Statute 224.43-010 states that it is the policy of the Commonwealth to provide for the management of solid waste, including reduction, collection, transportation, beneficial reuse, and disposal, in a manner that will protect public health and welfare, prevent the spread of disease and creation of nuisances, conserve our natural resources, and enhance the beauty and quality of our environment. One method listed to accomplish this is resource recovery through composting. Kentucky Revised Statutes 224 requires the Natural Resources and Environmental Protection Cabinet to adopt regulations for the handling of solid waste. The regulations and requirements of the general design and operation of landfarming and composting facilities are set forth in 401 KAR 48:200 and 401 KAR 45:100.

C. Compost Operator Certification

The Division of Waste Management is responsible for certification of compost operators. A training and certification program will be held for compost operators in Kentucky each year. The objectives of this program are to promote environmentally sound solid and special waste practices by training and certifying facility operators. The program includes sessions on waste characteristics, site selection, permitting, marketing, and operating requirements for a compost facility.

Who Must Attend: All compost facilities in Kentucky must have a certified operator. Any individual who is acting as the operator of a composting facility must register to attend the training session.

Upon successful completion of the examination, operators will become certified by the Commonwealth of Kentucky for a five-year period. Wallet sized certificates will be issued to all successful certification candidates. These certifications must be available for inspection whenever these individuals are operating a composting site. Certificates may be revoked if obtained fraudulently or the operator fails to comply with permit and regulatory conditions.

A fee is charged for the training school and certification program. The course may be taken for training only for a lower fee. This fee includes the training class and a manual for each participant. Attendance priority will be given to operators needing certification. Training manuals will be mailed in advance where time permits.

Study Question – Section 1

1. ______ to ______ pounds of solid waste is generated nationally per capita per day.
2. _____________ waste includes sludge from both water treatment and wastewater treatment facilities
3. ___________waste includes municipal and industrial solid waste.
4. ___________solid waste includes household and commercial solid waste.
5. The ____________ _____________ _____________ requires the Environmental and Public Protection Cabinet to adopt regulations for the disposal of solid waste.
6. All compost facilities in Kentucky must have a _______________ ______________.
7. Upon adequate completion of the examination, compost operators will be certified for a __________ year period.
8. Certificates may be ____________ if obtained ______________ or the operator fails to comply with permit and regulatory conditions.

Section II - Components of Solid Waste

Municipal solid waste can be divided into two categories: one that cannot be composted (residuals) and one that can be composted (biodegradable).

Non-compostable waste includes items such as aluminum and other metals, glass, plastic, etc. Typically, these materials may make up twenty-five to thirty-five percent of a community's waste stream. Much of this material can be marketed through recycling programs and represents a significant potential reduction in waste going to landfills. Potentially this leaves an even greater portion that can be composted.

COMPOSITION OF AN AVERAGE COMMUNITY'S GARBAGE

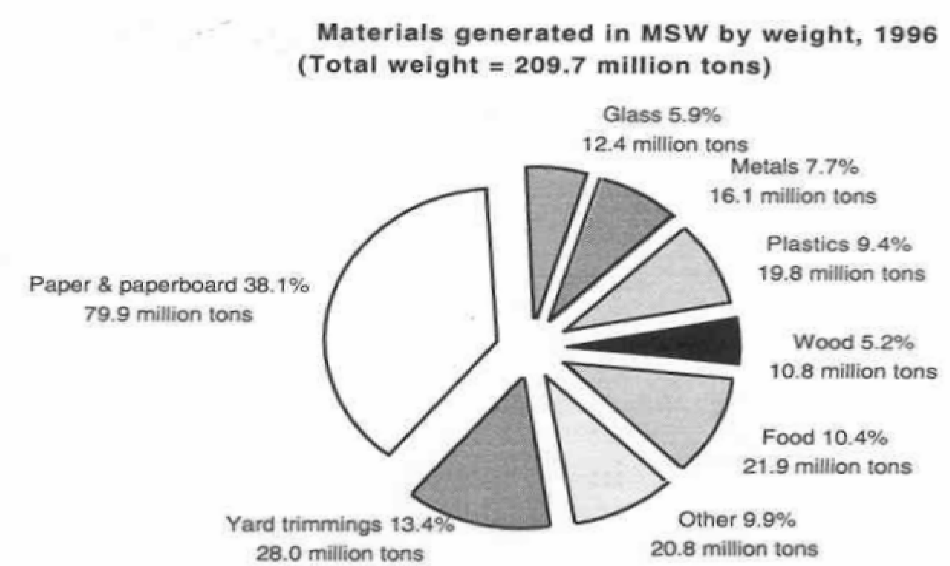

Figure 2-1 Composition of Average Community's Garbage
Adaped from Characteristics of Municipal Solid Waste in the United States: 1997 update, prepared by Franklin & Associates, LTD. for US EPA (Prairie Village, KS May 1998.)

Compostable waste includes all items that will rot, decay, or readily decompose. In general, this waste is organic in nature (i.e., remains of once living plants or animals). Yard waste (grass clippings, leaves, limbs, branches, and other wood products) and paper usually make up the bulk of compostable material. With proper management, these organic materials can be diverted from the waste mainstream and converted into compost. "Special waste" such as sludge from wastewater treatment facilities is also generally compostable. The inclusion of sludge with other municipal solid waste requires greater composting management skills and is subject to different permitting requirements.

Often materials from industry and manufacturing plants contain a sizable portion of organic components that can be composted. While these sources may not be included in municipal planning estimates, they can represent a significant source of materials for a compost operation. Like waste from municipalities, they should be adequately sorted before arriving at the compost facility. If questions arise about waste quality or elemental content, analysis of the materials should be evaluated before composting.

Study Questions – Section 2

1. Yard waste makes up ____ percent of an average community's garbage.
2. Compostable solid waste includes all items that will ________ or __________.
3. Non compostable solid waste includes items such as _______________,

   ___________, ______________, and ______________.
4. ______________, ________________, _______________, ____________________and

   ______________ usually make up the bulk of compostable materials.
5. Special waste such as _________________ is generally compostable.

Section III - Why Compost?

Composting is the natural decomposition of organic materials, at an accelerated rate, under managed conditions. Acceleration aspects result from controlling factors that affect composting. Composting is an important option for waste disposal since reuse, in the form of compost, is the result. Since as much as 65 to 75 percent of the waste stream may be compostable, this option can significantly reduce the amount of waste going to landfills. Thus, composting is one viable aspect of waste management with positive environmental results.

Compost (the product) may be used as mulch, soil amendment or as a minor source of nutrient addition. The use of compost as mulch may be the largest single use. Placing the compost around shrubs, trees, flowers, and garden plants as a mulch provides a means of reducing runoff through higher percolation and higher water holding or water retention capacities. In addition, mulch also reduces the amount of water evaporation by restricting the amount of sunlight reaching the soil thus cooling the soil surface. This cooler soil surface reduces the evaporative rate and loss of water resulting in less frequent watering. During times of extended drought or high temperatures, the mulch may even prevent plant death. A layer of organic mulch will also reduce competition from weed growth.

Compost may also be incorporated into the soil as an amendment. Mixing compost in the soil increases pore space allowing increased water permeability and aeration. Both result in an enhanced environment for plant root growth. As incorporated material continues to undergo further decomposition, the fertility of the soil may be enhanced. However, most organic waste does not have large quantities of nutrients. Runoff and resulting erosion are significantly reduced using compost as mulch. Eroded soil (suspended soil particles) is the number one pollutant in waters in Kentucky and in the nation.

Composting also preserves landfill space. The elimination of yard waste from the landfill may reduce the municipal waste stream by as much as 18 percent. Many communities understand this opportunity and have banned leaves and grass clippings from landfills. Yard waste is probably the most easily compostable material and the most logical waste for communities to initially divert from landfills. Composting any degradable portion of waste as well as sludge may reduce the waste stream by as much as sixty to seventy percent.

As yard waste and other materials are diverted from landfills to composting, tipping fees are often reduced for those materials. Transportation costs may also be reduced, depending on site location.

Composting operations may require "start-up" funding for land, operation or equipment. Profitable private operations require a "tipping fee" on the front end as well as sales revenues generated on the end product. In most instances, if fees allotted for composting approach fifty percent of the tipping fees for landfills, the composting operation will likely be financially successful. As the level of sophistication of composting increases, i.e. windrow to static pile to in-vessel, costs increase as do required management skills. The up-front "tipping fee" needs to cover the operational costs of the composting method.

Table 1. Densities of Yard Wastes

Material	Condition	Typical Density (lbs./cu yd)
Brush and dry leaves	loose and dry	100
Leaves	loose and dry	200-260
Leaves	shredded and dry	250-450
Green grass	compacted and moist	500-1100
Green grass	loose and moist	350-500
Yard waste	as collected	350-930
Yard waste	shredded	450-600
Sewage sludge	very moist	1100-1700
Wood chips	variable	400-650

Study Questions - Section 3

1. ________________ is the natural decomposition of organic materials at an accelerated rate.
2. Compost _______________ the surface, restricting the amount of sunlight reaching the soil. Thus, the temperature in the soil remains ____________.
3. The process of mixing organic waste into the soil tends to ______________ pore space allowing ________________water permeability and aeration.
4. Most organic waste does not have _____________quantities of nutrients.
5. ______________ and _________________ are generally reduced through the use of compost as mulch.
6. ______________ is the number one pollutant in the waters of Kentucky and the nation.
7. ________________ preserves landfill space.
8. Composting operations may require start up funding for ______________, ____________, or ________________.
9. ____________ _____________ is probably the most easily compostable materials.

Section IV - Essential Components Composting Processes

Composting Process

The composting process has the limitation of biological systems, and composting is affected by the basic conditions that affect microorganisms. The composting process is directly dependent upon the well being of the microorganisms. Air, water, temperature, particle size, and pH are all importing environmental factors in composting.

In composting, "decomposition" is used because the process is rarely carried to complete "stabilization". The term "biological" distinguishes the process from chemical and physical treatment. The "organic" term describes materials of a carbon source that are capable of being broken down biologically. "Controlled" distinguishes composting from the natural rotting, putrefaction, or other decomposition, that takes place in an open, unmanaged condition.

A. Microorganisms

The microorganisms that readily decompose or compost organic materials are naturally occurring throughout nature, including on the waste material. Thus, there is no need to purchase "compost starter" materials. The microbe populations may double several times per hour when favorable conditions exist (Table 2) resulting in accelerated organic matter decomposition. This decomposition, actually the metabolism of a food source for the microorganisms, results in the generation of heat. Thus, the temperature of the composting material will rise which is the most obvious indicator that composting is occurring.

Table 2. Optimal Composting Conditions

Oxygen	5 to 20%
Moisture	40-60%
Carbon:Nitrogen	25-40:1
Temperature	90-140 F (32-60 C)
pH	6-8

B. Aeration

Composting can either be carried out aerobically (with oxygen) or anaerobically (without oxygen). Most conventional composting methods use the aerobic process in which oxygen is essential (Table 2). Aerobic composting is characterized by high temperatures, the absence of foul odors, and is more rapid than the anaerobic process. By definition, Kentucky statutes consider only aerobic processes to be "composting".

Oxygen is added to the composting materials either by passive or active means. If the pile size remains small to moderate and particle size is medium to large, fresh air can passively diffuse in from outside the pile. Materials that have smaller particle sizes tend to decompose more rapidly. Materials such as grass clippings must be placed in smaller piles or windows, or have a significant amount of "bulking agent" to create larger pores to allow passive movement of enough oxygen into the decomposing materials.

An important aeration technique during composting is to regularly turn or mix the materials (actively add oxygen). The frequency of turning or mixing depends on the internal temperature of the material, the outside temperature, and the need to provide enough oxygen to the material. The first turning should occur when internal temperatures reach 140-150^{o}F following a steady temperature increase. However, if the internal temperature "peaks" or levels off at 100-120^{o}F before the first turning or mixing, the pile should be turned immediately to avoid going anaerobic as oxygen may be limiting. As the number of turnings increase, the peak temperature reached, after each turning, may be lower than the previous peak temperature. Also, as the number of times the material is turned or mixed increases, the particle size becomes smaller making it more important that close attention be given to temperature and aeration.

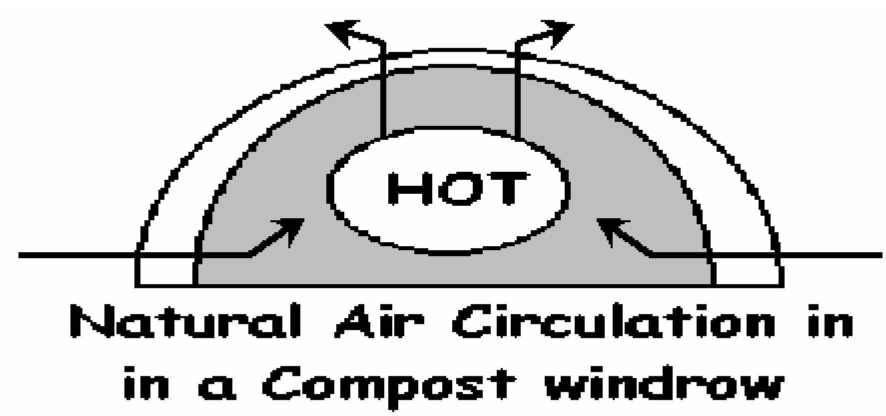

Figure 4-1 Air Circulation Through a Compost Windrow

Anaerobic composting is characterized by low internal temperatures, the production of odorous immediate products, and a slower rate of decomposition. This system is usually not economically feasible, and frequently produces compost that may be toxic to living plants. The most common complaint of neighbors to compost operations is offensive odors, which can occur when the process goes anaerobic. Once the process goes anaerobic, the compounds produced take a long time to be converted back to aerobic conditions to make a desirable product. When anaerobic-type odors are released during the composting process, this usually indicates poor management.

C. Temperature

The activity of biological systems is temperature sensitive. Consequently, composting rates are determined, at least partially, by the temperature within the pile or windrow. Table 2 suggests the optimum temperature is between 90°F and 140°F. As the temperature approaches 140°F, fewer microorganisms can tolerate those temperatures and composting rates will decrease.

Size of the pile or windrow and porosity of the material determine how readily heat escapes. Larger windrows and smaller particles provide greater insulating effect and slower heat loss. Figure 4-1 shows general temperature concentrations in a windrow. "Turning" the composting material permits the excessive heat to escape. After "turning" the composting material, the temperature will start to rise again. When only a slight heat increase (10°F above atmospheric temperature) or no increase, in windrow temperature occurs after several times of turning, and if all other environmental factors are favorable, stabilization of the compost has occurred.

D. Moisture

Adequate moisture levels in the composting material are another necessary component of "good" composting. Biological systems require adequate moisture or a moist environment. When the material is too dry, microbial population expansion will be slow, temperature will not rise as fast, and composting will proceed more slowly. Sometimes if the moisture level is too low, the material will "mold" and not proceed to compost.

Excess water or moisture in the material reduces the aerobic microbial population. Also, some of the excess moisture fills pore spaces between the particles which restricts normal passive flow of oxygen into the material and promotes the more rapid development of anaerobic conditions. This suggests that more attention must be given to managing aeration and temperature during the early stages of composting.

The balance between adequate moisture and aeration often becomes an important management consideration. Combinations of materials that include significant amounts of paper or paper products may need to start the process at 65% moisture. Composting mainly non-woody yard waste, a mixture of leaves, and grass clippings, may not need an addition of water in a climate such as Kentucky. Conversely, woody material will very likely need additional moisture, unless freshly cut, as they tend to contain less moisture upon delivery and are very porous. Porous materials often dry faster, especially in warmer weather. Some of the faster drying can be reduced with the use of finer materials (leaves, grass clippings, or sewage sludge). These finer materials not only reduce the rate of drying, but also help the total mixture retain moisture for a longer period.

E. Carbon : Nitrogen Ratio

The two most important nutrients needed for microbes to grow and reproduce are carbon and nitrogen. Consequently, the concept of carbon to nitrogen (C:N) ratio must be understood if composting is to be successful in recycling some of the waste stream. For optimum composting, the C:N ratio should be in the range of 25-40:1 (Table 2). Keeping the range in the low 30's is more beneficial when starting the composting. If the total C:N of the material in the piles or windrows is less than 20:1, they will give off ammonia. The microbes release the extra nitrogen as ammonia in the process of breaking down the carbon containing materials which can generate odor complaints from neighbors.

Carbon is high in carbohydrates and in cellulose materials such as paper, wood, woody plants, some plant residues, and leaves. Energy for the microbes is obtained by breaking down these substances and releasing carbon dioxide.

Nitrogen, found primarily in proteins, is necessary for the development of microbial proteins that balances the carbon for rapid growth and expansion of microbial populations to ensure a reasonable rate of composting. The nitrogen content of organic materials is often the most limiting factor in composting. Nitrogen content is low in paper, woody materials, and some plant residues, and high in grass clippings, sewage sludge, animal manures, and some food waste. Understanding the importance of the C:N ratio and knowing the C:N ratio of various materials for composting enables a good manager to maintain optimum composting conditions. Estimates for some materials are contained in Table 3. Keep in mind that these values will vary. For example, highly fertilized lawns will have lower ratios, and unfertilized lawns will have higher ratios. In addition, C:N ratios in leaves from some hardwoods (oak) will be higher than from some other trees (maples).

Blending of low C:N materials with high C:N materials or commercial nitrogen fertilizer is important to avoid some problems, and to speed decomposition. Sawdust or finely ground wood can be combined effectively with an appropriate amount of grass clippings, sewage sludge, or animal manure to optimize the C:N ratio. When using sawdust in composting, the high C:N ratio of wood should be taken into account when estimating C:N of the total mixture. When large (3/4 inches or larger) wood chips are used as a bulking agent (maybe 10% of the mixture), passive airflow into the composting material will increase. This volume of high C:N material is usually not accounted for as microbes decompose little of these larger wood chips. The addition of commercial sources of fertilizer nitrogen may be used to lower the C:N ratio if low C:N materials are not available. This may significantly add to the composting cost, and may not be acceptable for some "organically" inclined gardeners or homeowners. As an example, mixing leaves (40-80:1 ratio) with a high nitrogen waste, such as grass clippings, animal manure, or commercial nitrogen fertilizer will accelerate composting. Adding 1 part grass clippings to 3 parts leaves, or 1 to 2 lbs. of ammonium nitrate or urea fertilizer per yd^3 of leaves, will balance the C:N ratio.

However, the addition of commercial sources of fertilizer nitrogen is usually not necessary for most non-woody or non-paper wastes.

Table 3. Carbon to Nitrogen Ratios

Material		C:N
Sewage Sludge:	Activated	6:1
	Digested	16:1
Humus		10:1
Food Wastes		15:1
Grass Clippings		19:1
Cow Manure*		20:1
Horse Manure*		25:1
Fruit Wastes		35:1
Foliage		40-80:1
Corn Stalks		60:1
Straw		80:1
Bark		100-130:1
Paper		170:1
Sawdust		500:1
Wood		700:1

* C:N ratio includes bedding

F. Particle Size

Particle size of the materials to be composted influences the rate of composting. Small particles, that create a high surface area per unit of volume, allow the nutrients and energy to be more available to the microorganisms for successful, efficient composting. Shredding, chopping, and grinding create smaller particles, which expose more surfaces to microbial activity. Because these smaller particles may restrict passive air flow and increase oxygen demand of the microbes, finer materials need to be turned more frequently to prevent anaerobic conditions during composting.

A more homogeneous compost is often more important in establishing a good market. The major problem with the absence of grinding, shredding, or chopping is the lack of a homogenous product. If a small particle material, such as sewage sludge, is mixed with a larger particle-bulking agent, grinding may not be necessary. When the rate of composting is not a critical issue, then more time can be allowed for composting larger particles. This will require a larger site for composting and delay the formation of uniform, marketable compost. Some compost facility operators have found that shredding leaves will reduce time required to produce stable compost. This shredding can occur as part of collection or it can be performed at the composting site.

G. pH

pH is an indicator of the acidity or alkalinity of the composting materials, and is measured on a scale of 0 (extremely acid) to 14 (extremely basic), with 7 being neutral. The composting process is most efficient when pH is between 6 and 8, which are normal values (Table 2). This factor can be very useful in diagnosing and correcting certain operating problems.

During the initial stages of decomposition, organic acids are formed that are normally consumed by the microbes. However, without sufficient oxygen available to the microbes, these acids will not be converted to usable carbon or carbon dioxide as quickly. Thus, excess acidity may lower the pH below 6, and in turn slow down the composting process. This is more likely to happen when larger amounts of “simple” (easily composed) organic compounds are present (undiluted animal manure, some green wastes, etc.) Extra aeration though use of more bulking agent or more frequent turning will usually solve the problem. In extreme cases, it may be helpful to add some lime or other neutralizing agent to raise the pH back to a desirable range. It is also important to avoid raising the pH above 8, which can cause the release of odorous ammonia. If the starting materials were balanced for C:N, ammonia release in this instance may rob the composting process of sufficient nitrogen, which will slow the process.

Final compost pH can be a factor in marketing. Final pH above 8 can damage or even kill more acid-loving plants such as azaleas, rhododendrons, pine, or blueberries, especially if used in large quantities. Testing compost during decomposition or at the final stage can be very simple, and can be done on-site with a soil or plant media testing kit.

	pH SCALE	
Acid(H^+)	**Neutral**	**(OH^-)Base**
0============================	7	===========================14
Red	**Litmus Paper**	**Blue**

Figure 4-2 pH Scale

Study Questions – Section 4

1. The ____________ of the waste to be composted determines the rate at which the materials compost.
2. Composting involves the decomposition activity of microorganisms such as ________and ________.
3. The environmental conditions in which these microbes live determine the ____________and ____________ of their degradative processes.
4. ________________ ________________ is the most obvious indicator that composting is occurring.
5. The air we breathe has approximately ____________ percent oxygen.
6. At least ______ percent oxygen must be present for materials to compost.
7. ___________ is the vital component needed to maintain low levels of odors.
8. Turning the compost to maintain proper aeration should always receive __________ priority.
9. Composting _________ are determined partially by the ______________ within the pile.
10. Optimum temperature for composting is between ________ and ________.
11. _________ of the pile and _________ of the material determines how readily heat escapes.
12. High ____________ material may need more frequent turning for both aeration and temperature control.

13. Stabilization of the compost has occurred when heat _____________ do not occur after turning.

14. Adequate moisture levels in the composting materials are another necessary component of _____________ composting.

15. Excess water causes a deficient level of _________________.

16. There will very likely be a need for additional ___________ and ___________ to compost woody materials.

17. Microorganisms involved in composting have a greater need for ___________ and _____________ than they do for other nutrients.

18. ________________, found primarily in proteins, is necessary for the rapid growth and expansion or microbial populations to ensure a reasonable rate of composting.

19. Nitrogen content is high in ____________ and low in __________ products.

20. ___________ ______________ of the material to be composted influences the rate of composting.

21. Microorganisms need __________ surface areas to effectively decompose material. ___________ particles have high surface area.

22. Failure to grind coarse materials ___________ time required for composting.

Section V - Composting Methods

There are several different methods of composting organic materials. The methodologies vary in:

*Degree of technology used

*Attention paid to monitoring the operation

*Space needed for the active composting site

*Length of time available to obtain a finished product

*The ability or need to combine various materials

Because of the above, the costs will vary. In general, the lower the level of technology, the greater will be the need for available space, the larger the buffer zone, and the composting time longer. However, lower technology will tend to have the lowest cost per ton of material processed.

A. Windrow Composting

One of the most economical methods of composting is windrow composting. When windrow composting, the material is placed in windrow approximately six to ten feet high and turned or aerated mechanically. Grinding or shredding of yard waste and municipal solid waste will produce a more homogeneous mixture and likely accelerate the composting process. Front-end loaders or commercial windrow turners may be used to aerate and turn the material. Some commercial windrow turners may limit the windrow height to six feet or less.

Slight odors may develop during the windrow turning process, but these can be kept to a minimum through frequent turning and other good management practices.

Sewage sludge can be mixed with yard or municipal solid waste to form a blend that is very acceptable for the windrow composting process. Knowledge of the carbon: nitrogen ratio and moisture levels of all materials to be blended will greatly assist in determining the ideal mix.

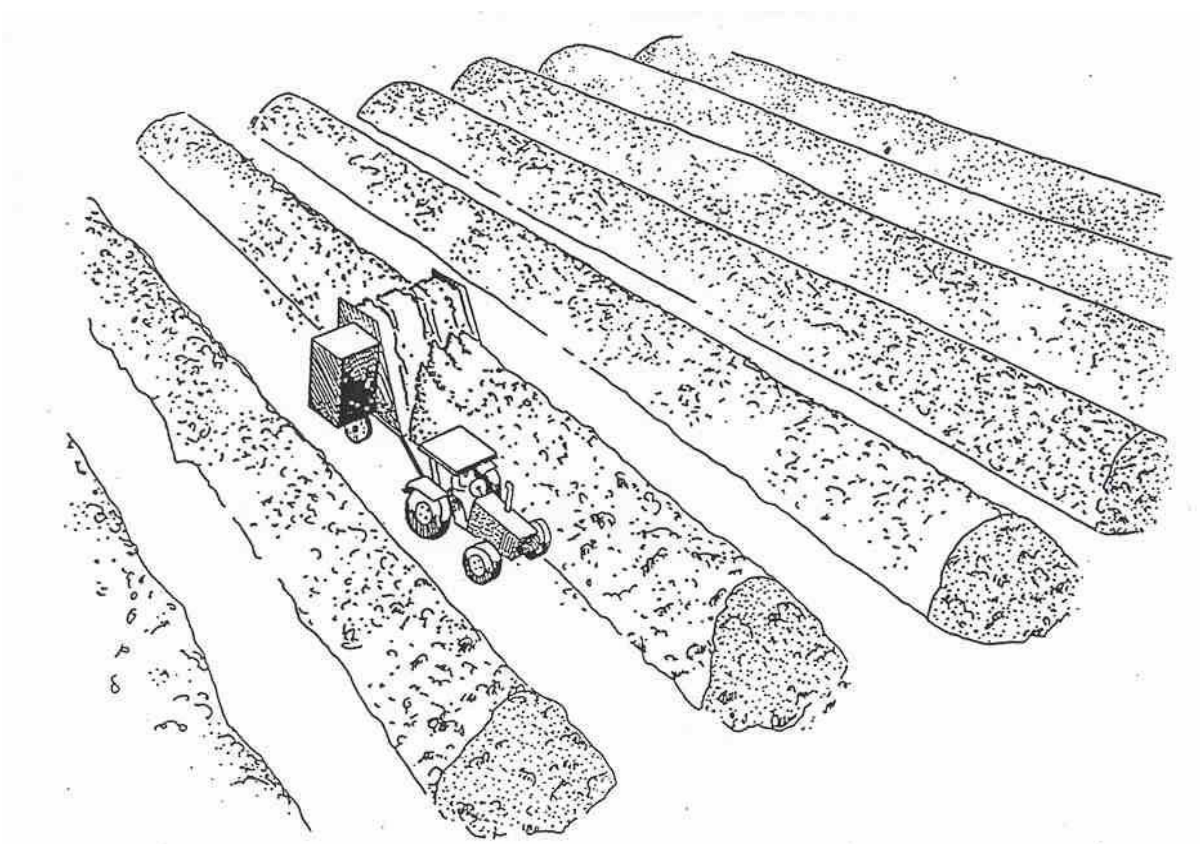

Figure 5-1 Windrow composting with an elevating face windrow turner. Adapted with permission from On-Farm Composting Handbook, NRACS.

Many municipalities have found the windrow composting process very acceptable as it frequently requires very little additional capital investment when using existing front-end loaders to turn the windrows.

The time required to produce stable compost will vary with the materials being composted. However, with leaves, a marketable product can be produced within four to five months. Woody materials will require up to a year or more, but this can be reduced through the blending of materials with a narrower ratio of carbon to nitrogen, i.e. sewage sludge. However, care should be taken to make sure the site is properly permitted to accept the types of wastes being composted.

B. Static Pile Composting

Static pile composting is somewhat similar to windrow composting except aeration and cooling is accomplished by forcing or blowing air through the windrow rather than mechanically turning. Normally a blower or fan, controlled by timers or thermo-switches, will blow air through perforated pipe located under or near the bottom of the windrow. This air moves through the windrow and out the surface. This air replaces the oxygen used by the microorganisms and carries away some of the heat. It is possible to maintain nearly optimum conditions in the windrow at all times, thus speeding the composting process.

Another advantage of the static pile system is less space is needed as the windrows can be placed very close together. Some projects have found it desirable to use both the static pile system and the windrow composting system. The static pile is used for the first few weeks when the most rapid decomposition is taking place and thus the demand for oxygen is greatest. The material is then moved to an adjoining area for mechanical aeration for the balance of the composting period.

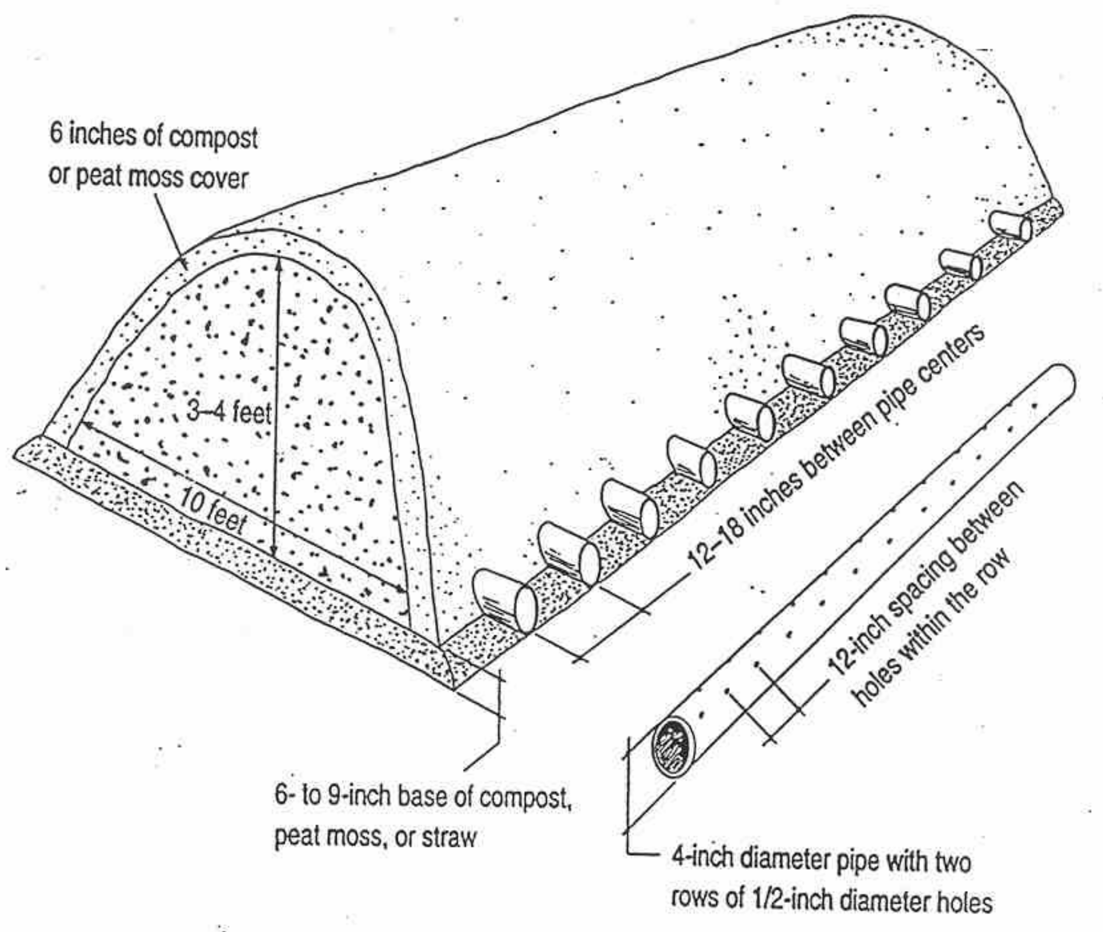

Figure 5-2 Passively aerated windrow method for composting manure. Adapted with permission from On-Farm Composting Handbook, NRACS.

The major disadvantages of the static pile composting procedure are the need for increased management and the dependence on electricity or another power source to operate fans and controls. Daily monitoring will likely be necessary even if materials are not being received or dispersed. The static pile system may be used under a roof or outside.

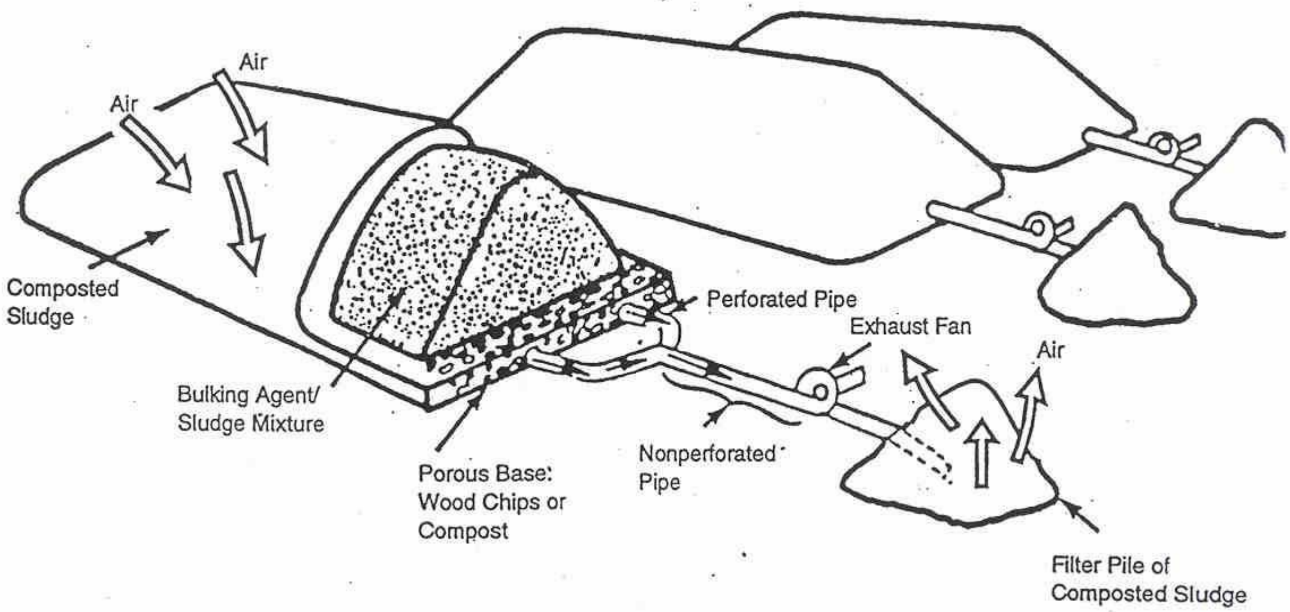

Figure 5-3 Static aerated pile composting
Adapted from Control of Pathogens and Vector Attraction in Sewage Sludge, EPA/625/R-92/013 December 1992

C. In-Vessel Composting

In-vessel composting includes a variety of systems involving mechanical agitation, and forced aeration, and is normally enclosed within a building. An in-vessel system is capital intensive and requires high levels of technology and management. However, an in-vessel system may incorporate more automation and thus reduce hours of labor per unit of material processed. Such a system may not be economically sound for yard waste or separated municipal solid waste but may be appropriate when sewage sludge is part of the materials to be composted.

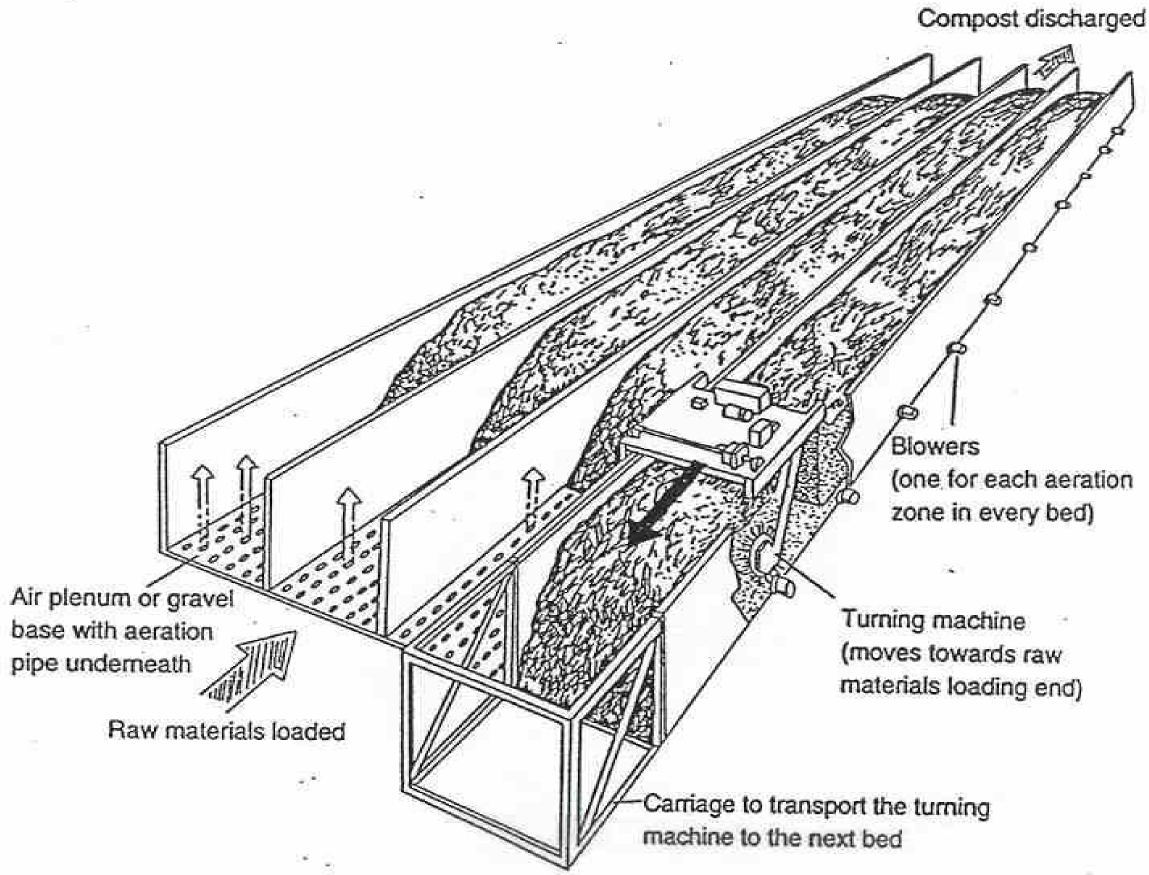

Figure 5-4 Rectangle agitated bed-composting system
Adapted with permission from Royer Manufacturing.

The major advantages of the in-vessel system are the avoidance of weather problems, faster processing, better odor control, and automation. Most in-vessel systems are designed and supplied by consultants and commercial suppliers.

With proper design and management, any of the above three composting systems are capable of processing yard waste, municipal solid waste, or special waste. The most appropriate process for any given community will be determined by available space, available capital, technical expertise, materials to be composted, and federal, state and local ordinances.

Study Question – Section 5

1. One of the most economical methods of composting is _______________ composting.
2. When windrow composting, the materials is placed in windrows of approximately ______________ to ________ feet high.
3. ____________ ____________ and ______________ _____________ may be used to aerate composting materials.
4. ____________ may develop during the windrow turning process.
5. By aerating static piles, _____________ is accomplished by forcing or blowing air through the windrow.
6. An advantage to aerated static pile composting is that __________ space is needed __________ can be place closed together.
7. The three major disadvantages to aerated static pile composting are:
   a. ____
   b. ____
   c. ____
8. ___________________ composting is usually enclosed within a building.
9. The three methods of composting are:
   a. ____
   b. ____
   c. ____

Section VI - Facility Siting and Preparation

The selection of the site for a composting project is a very important decision and should be made only after consideration of several facts starting with the determination of composting method to be used. Local ordinances and zoning codes must be one of the first items to be examined in the compost site selection process. Some other factors to consider in site selection include facility size, transportation, drainage, neighboring land use, and other sensitive issues. Check 401 KAR 30:031 for waste site requirements. All composting facilities must comply with these environmental performance standards.

A. Facility Size

The exact size of a proposed site is difficult to determine but must be adequate to not only handle materials for the present but also be capable of future expansion. Many communities have found that, as public acceptance of composting develops, more material becomes available for composting. In addition, most urban communities are growing in area and population, thus expanding the number of households to be served. To allow for adequate space for receiving materials, equipment storage, compost windrows and related activities, the windrow or static pile composting system will require approximately one acre of land for every 3,500 to 5,000 cubic yards of material to be received. Therefore, a five-acre site would be needed for 14,000 to 20,000 cubic yards of material received each year. The in-vessel system will require less space but consultants may be needed in the determination of total space needed for buildings and service areas.

B. Transportation

Because of the large quantity of materials being delivered to a composting site, transportation is of major concern. For example, a 20,000 cubic yard operation may mean that 600 truck trips will be needed if each truck had a 30-35 cubic yard capacity. In addition, the end product must be marketed so additional trucking will be required. Because of this large truck traffic, suitable all-weather roads must be available or budgeted for construction. If the marketing is to be through on-site sales to local customers, ease and convenience of access must also be considered. Therefore, close proximity to the local population but with a certain level of isolation is desired.

Figure 6-1 Transportation

C. Drainage

The ideal outdoor compost site should have a slope of 1-3% to reduce ponding. In addition, the site should be located so no off-site water is allowed to run onto the site. Some form of water containment will likely be required to prevent runoff of the site from entering streams or other water sources. In many parts of Kentucky, sinkholes are another obstacle in site selection. No runoff shall be allowed to flow into these sinkholes.

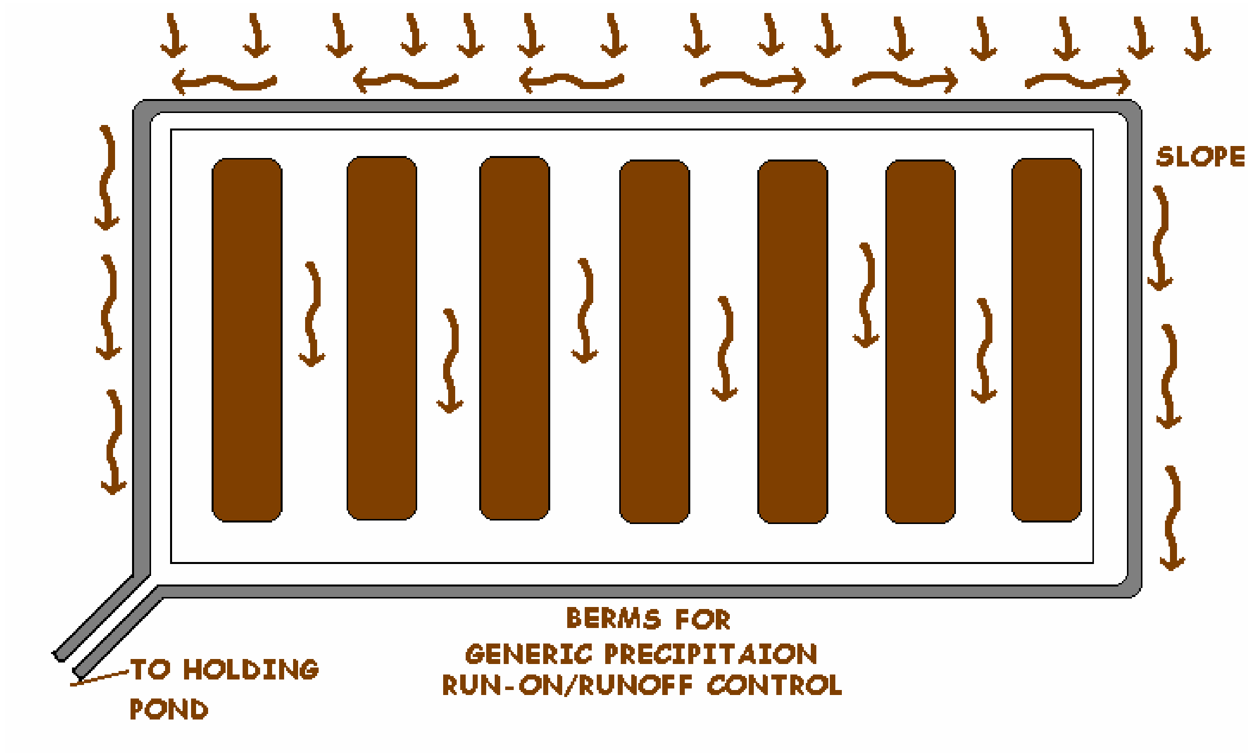

Figure 6-2 Generic Run-on/Runoff Site Plan

As an in-vessel-composting site will likely be located under roof, runoff is of less concern. However, large buildings with adjoining blacktop-parking areas may present major water control problems. Some communities require detention or holding ponds for this water. Check with local agencies prior to construction.

D. Neighboring Land Use

Some type of buffer zone is needed around a compost site. While proper management will keep odors to a minimum, some odors will be developed, especially during the windrow turning operations. The noise and dust created by the truck and heavy equipment operations should also be considered in determining the buffer zone. A minimum of 500 feet between the composting site and the nearest residence is recommended. A row of trees helps greatly in serving as a visual and sound screen for a compost site.

In-vessel composting will normally be less of a potential problem for the surrounding community, but even this system can produce undesirable odor and noise problems. An in-vessel system will not have any reduced truck traffic over other composting systems.

E. Water

The composting of leaves and grass may require no additional water. However, to compost woody materials, additional water is frequently required. Some of this additional moisture requirement may be met with the moisture in sewage sludge if this material is incorporated in the compost. However, a good water supply should be available at any composting site. When a building is involved, fire codes should be checked to determine if there are stated water requirements. A nominal water supply is needed for equipment maintenance and cleanup.

F. Security

Security at a compost site is not likely to be a major concern. However, some form of security is needed to prevent theft and vandalism to equipment and illegal dumping of unwanted materials. A secure building for equipment and a fence and gate with lock may be adequate. Restriction of public access at compost facilities is required by state regulations.

G. Safety

Safety should always be of major concern when working around heavy equipment, areas with a combination of moisture and electricity, and where automated equipment may be operating. All of these conditions may exist at a compost site. All personnel must be informed of all relevant OSHA rules, regulations, and code requirements. They must also have had proper instruction on the safe operation and maintenance of all equipment that they are to operate. This knowledge will likely require some form of formal and documented instruction. It is imperative that federal, state, and local rules and regulations be known, understood and followed. Appropriate first aid equipment should be available in case of an emergency. Most areas at a compost site may be declared a “hard-hat” area. Check with appropriate authorities on this issue.

It is also a good safety practice to have two or more individuals at a site when equipment is being operated. A telephone or radio system at the site will add to the safety.

Continual exposure to the dust, spores, and vapors of the compost should be avoided. When working at an outside operation, one may be able to reposition equipment to keep operators "up-wind" and free of dust and odors. However, some sites may require masks or other respiratory aids. Eye and ear protection devices may also be needed. All machinery should have fire extinguishers or have easy access to fire extinguishers.

One should check with local safety officials during the planning stage of a compost site to assure that all appropriate safety features are built into the system. In addition, a continual monitoring and reporting system should be part of the overall safety program.

H. Water Table and Percolation

No compost site should be located where either a high water table or flooding is likely to cause standing water to come in contact with the material being composted. The USDA Soil Conservation Service can provide advice on drainage and percolation of the soils being considered for a composting site.

Study Questions – Section 6

1. Some factors to consider in site selection of a compost facility include:

   a. ____

   b. ____

   c. ____

   d. ____

2. The proposed site of a composting facility must be able to handle present materials and be capable of ______________________________.

3. ____________ ______________ and _______________ must be one of the first items to be examined in the compost site selection process.

4. Because of large truck traffic, suitable all-weather ____________must be available at composting facilities.

5. The ideal outdoor compost site should have a slope of _______ to reduce ______________.

6. Some type of ________________ ______________________ is needed around a compost site.

7. In many parts of Kentucky, sinkholes are an _____________ in site selection.

8. The ____________ and ____________ created by the trucking and heavy equipment operations should be considered when determining the buffer zone.

9. A _____________ _________________ __________________ helps greatly in serving as a visual and sound screen for a compost site.

10. Some form of security is needed to prevent __________________ and ______________ at compost facilities.

11. Appropriate __________________________ ____________________________ should be available in case of an emergency.

12. A continual _______________________ and _____________________ system should be part of the overall safety program.

Section VII: Composting Procedures

There are several levels of technology available for composting projects, i.e. windrow, static pile, and in-vessel composting. The one that is best suited to any particular community will depend primarily upon the existing or proposed collection/separation system, site selection, equipment, available labor, materials to be composted, and the market for the resulting compost. Economics plays a very important role in composting as the market value of the end product is relatively low.

Figure 7-1 Collection

A. Collection

The collection of yard waste may be accomplished through several approaches but must be tied in with the composting system. The least expensive method may be to have residents deliver their waste to either the compost site or selected drop-off centers. However, this method of collection may limit participation and, unless someone is on hand to monitor the materials dropped off, considerable contamination may result. Some communities have found that providing several containers for different materials at the drop-off sites can reduce this contamination.

The use of plastic bags to collect materials for a compost site is to be discouraged. Plastic bags require excessive labor to open and separate and are totally unsuitable for grinding and mixing with the material for composting. However, paper bags are suitable for composting, as they will decompose along with other organic material. Another disadvantage of bags is the risk that undesirable materials such as rocks, cans, bottles, or other materials may be included in the bag. This may damage machinery used in the composting procedure and produce an undesirable end product.

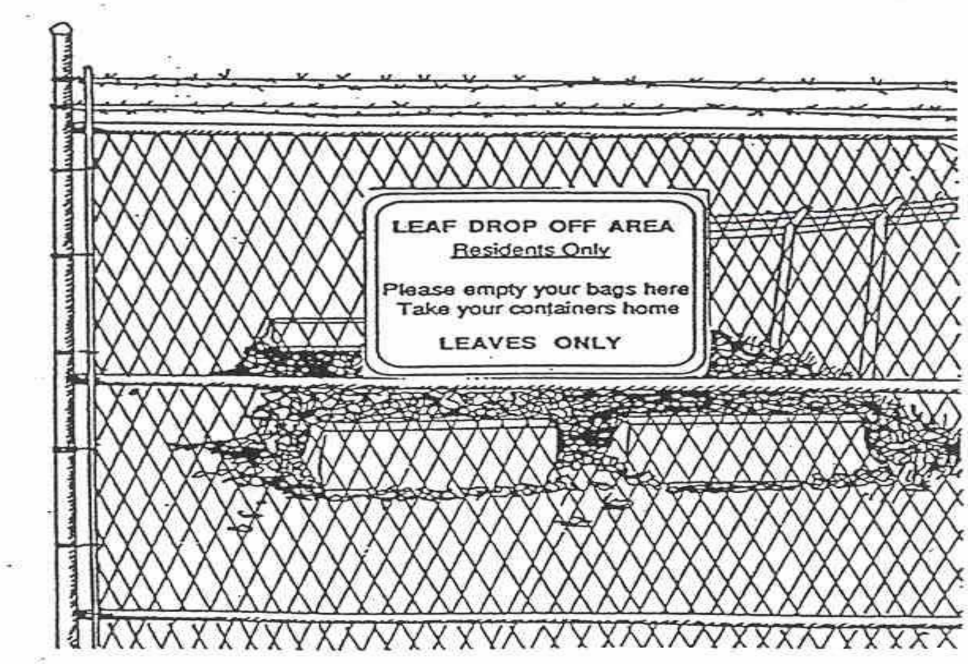

Figure 7-2 Leaf Drop-off Area

The use of front end loaders to pick up compostable material may be rather labor efficient but may also allow rocks, bottles and other foreign items to become incorporated into the materials for composting. One advantage of this system is that most municipalities already have loaders and trucks, thus no additional equipment may be required.

Another system that has worked very well for some communities is the vacuum type pickup machine that blows the leaves directly into trucks. While this will require a crew of three to five people for each set of machinery, it allows them to pick up more material in a shorter amount of time. It also alleviates the need to separate the compostable material from plastic bags.

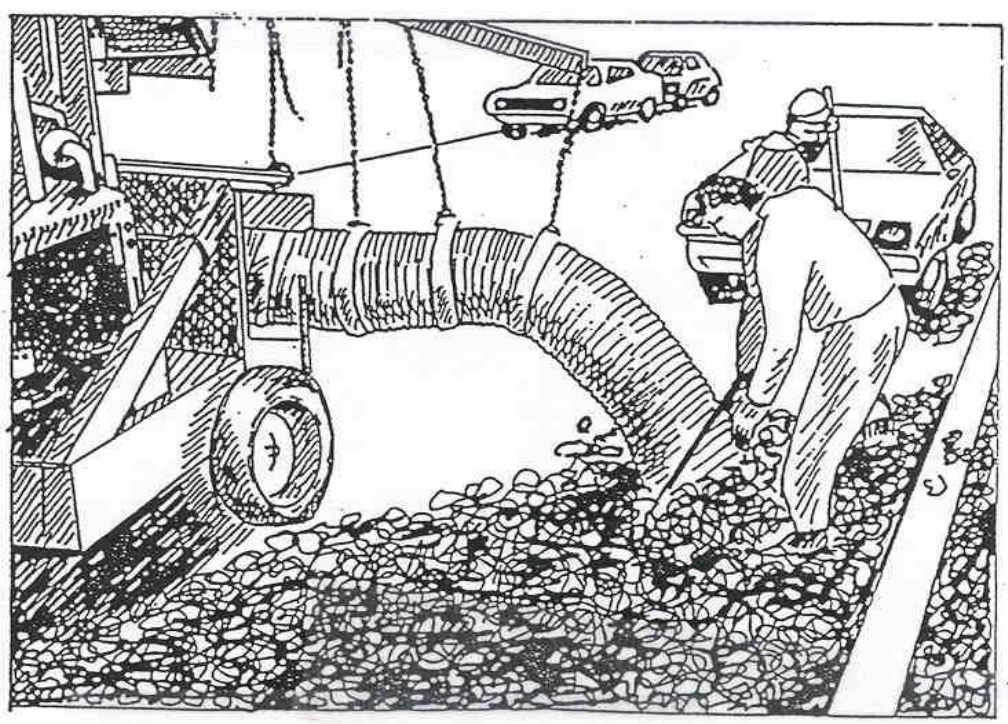

Figure 7-3 Vacuum Truck Collection

Some communities have developed a "resource recovery system" whereby all waste materials are delivered to a common site and separated. Under this plan, all compostable items are separated and sent to the compost site. This system may provide a greater mixture of products being received at the compost site and will likely increase the amount being diverted from the landfill stream.

Sludge will likely be delivered to the compost site directly from the treatment plant by truckload lots. The moisture level of this material may require special handling. This should be well understood at the planning stages if sludge is to become a part of the composting system.

B. Receipt of Materials

As the materials for composting are delivered to the site, it may be necessary to place this material in piles or windrows in order to conserve space. This can normally be accomplished with a front-end loader. For smaller projects of 3,000 to 5,000 cubic yards of material each year, a farm type tractor with front-end loader may be adequate. However, four-wheel drive or front wheel drive assist may be necessary for all weather traction.

For projects larger than 5,000 cubic yards, a four-wheeled drive industrial loader, with a bucket of two cubic yards or more, will be the best machine for moving the materials into windrows. Windrows or piles should be positioned on the site slope parallel to the natural flow of water to prevent ponding of water. Ponding of water will develop undesirable anaerobic conditions. Ponding may also cause equipment problems with mud holes developing in the ponding areas.

Figure 7-4 Turning Windrows Using a Bucket Loader.
Adapted with permission from On-Farm Composting Handbook, NRACS.

Sludge, grass clippings and other municipal solid waste may contain high moisture and/or nitrogen levels. This material may develop undesirable odors and draw flies and other vectors if not handled properly. It is important that a system be available to identify the content of the materials being received, in order to mix and blend the materials to the desired conditions. This may mean that it is necessary to maintain a supply of drier material that has a wide Carbon:Nitrogen ratio. Ground brush, chipped wood, shredded paper, ground pallets, or even straw may serve this purpose. With good planning, a compost site manager should be able to mix and blend materials that are not well suited for composting individually, into a very compostable blend that has little risk of the production of odors.

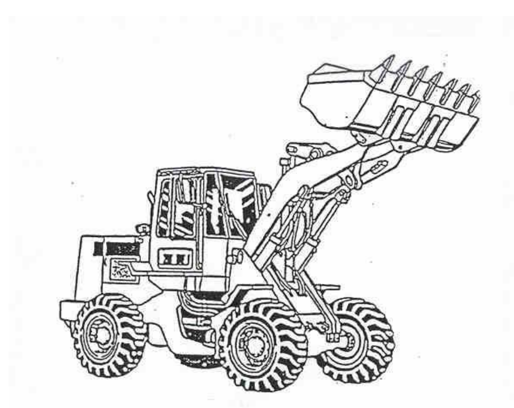

Figure 7-5 Articulated Loader

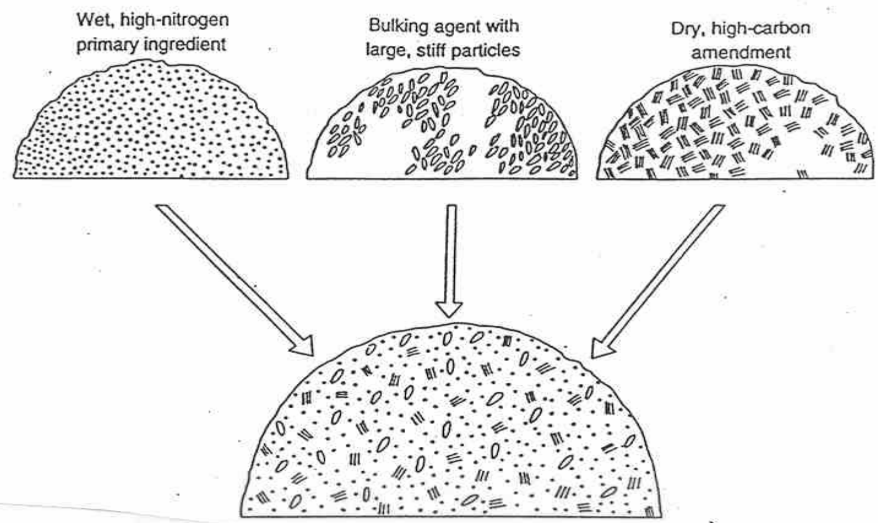

Figure 7-6
Combining Raw Materials to Achieve the Desired Characteristics for Composting. Adapted with permission from On-Farm Composting Handbook, NRACS

C. Grinding or Shredding

Some communities do not grind or shred leaves in their composting projects. However, grinding greatly enhances the speed of decomposition and produces a more uniform and desirable end product. Brush and wood will require some form of grinding or shredding. While it is desirable to grind or shred the leaves or other yard waste as soon as they are delivered in order to speed up the decomposition, the timing of this is not crucial. This may enable the project to spread its workload more evenly. However, when receiving grass clippings or other putrescible wastes, it is necessary to mix them with other materials within 24 hours. If left unattended grass clippings will develop undesirable odors in a very short time. This is due to the high nitrogen and moisture content of the grass. Grinding or shredding not only reduces the size of the particles but also serves as a very good mixing system.

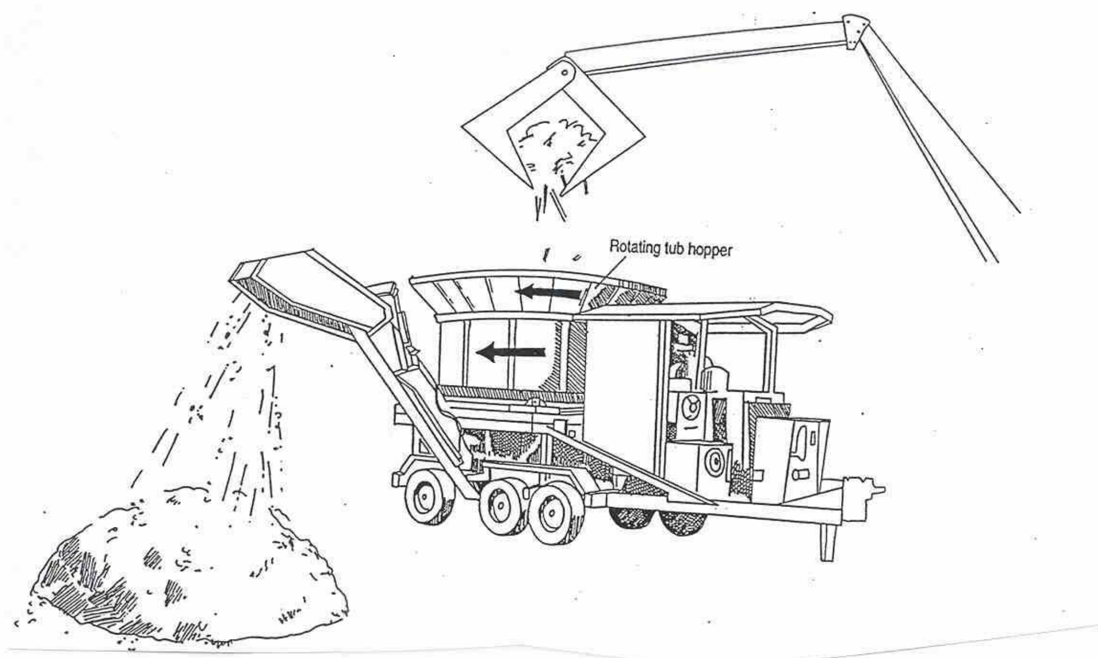

Figure 7-7 Tub Grinder
Adapted with permission from On-Farm Composting Handbook, NRACS

There are many different grinding and shredding machines available and new machines being developed. Careful consideration must be given to not only the present but also future needs. A project initiated to process only leaves may expand into other yard waste, industrial waste such as pallets, sawmill waste, or even construction demolition debris (CDD) waste. A machine capable of handling CDD waste could process leaves but a smaller machine designed for leaves only may not be able to process the CDD waste. One potential answer for smaller projects or projects not sure of future growth and expansion is to utilize custom grinding services. Such services have become available over the last few years with services being offered on a one-time basis or a regular interval schedule. Charges may be by the hour, day, or ton of material processed.

D. Windrow Formation

For the best results, the compost needs to be kept in the aerobic state. This is most often accomplished by placing the material in windrows. The windrow is an elongated compost pile usually 6 to 10 feet high and up to hundreds of feet long. These windrows need to be placed parallel to surface water drainage. The distance between windrows may need to be approximately 20 feet to allow for movement of equipment in the turning or aeration process. Care should be taken to avoid running equipment onto the composting material. This will compact it and reduce the air (oxygen) content, thus increasing the need for frequent turning.

In the static pile composting process, the material will be placed over the perforated ducts and fans will be used to force air through the material. For in-vessel composting the mixed material will be placed in compartments for mechanical turning and aeration.

E. Balancing the Process

1. C:N Characteristics

Generally, supplying C and N at the suggested ratio ensures that other nutrients will be available to the microbes in the correct amounts. Initial C:N of 25-35:1 will consistently bring good composting results. Ammonia will be lost when the C:N dips below 20:1. As the C:N moves toward 40:1, the microbes may slow slightly until the excess C has been oxidized. If the C is in a form that is difficult to decompose, such as lignin from wood or paper, the rate of stabilization will be slow. Green wood is an exception as the sugars in the sap are more available to microbes thus allowing more rapid composting. Fungi are the only organism that can efficiently decompose woody materials (heartwood) and they will not survive above 140^{o}F. The rate of composting for woody materials begins to slow above 130^{o}F.

When composting is starting, microbes usually begin on the lower C:N materials making it important that the materials be well mixed. Often in the low technology windrow system, inadequate mixing leads to hot spots that need more frequent monitoring and may need to be turned more frequently before the temperature of the total windrow reaches an optimum level. Because the mobility of the microbes is negligible, it is necessary to provide intimate contact between the microbes and the waste materials. This is done by grinding some wastes and thoroughly mixing all wastes.

2. pH Properties

The optimum pH range is 6 to 8 due to the broad spectrum of microbes involved in composting. The natural buffering capability of compost often permits a wider range for short periods. However, as noted earlier, the process can become too acidic (low pH) with generation of organic acids particularly in wastes with high protein contents, and should not go above 8.0 to avoid ammonia loss. Most stabilized compost will have a pH between 6.5 and 7.5.

3. Porosity, Texture, and Structure

The porosity, material texture, and structure affect composting by what influence they have on aeration. Porosity determines airflow resistance and is related to overall particle size and variation in particle sizes of the materials. The spaces between particles must be connected to allow adequate airflow into the area of microbial activity. Large particle size and a uniform sizing of materials result in higher porosity. Material structure is derived from particle rigidity, and is determined by an ability of the composting mass to resist settling. Some height reduction will occur during composting from loss of carbon dioxide and reduction in particle size.

Material texture controls the surface area available for microbial activity. Microbial activity is largely confined to the surface and edges of particles, thereby they utilize the oxygen present in a thin film on the surface or edge of the material. As surface area increases with a decrease in particle size, the rate of microbial activity increases given that adequate oxygen can be maintained. However, there are limits. When particle size becomes too small there is a loss of porosity making a compromise necessary.

Moisture content of the mixture of materials influences porosity. Excessive moisture causes a loss of porosity by filling many of the spaces between particles. Materials such as leaves and paper lose their rigidity when wet. Any detrimental effects of excessive moisture are not critical until materials have greater than 60% moisture.

Predicting porosity characteristics of the mixture from individual materials is nearly impossible. However, bulk density of the total mixture of materials can be used to give some assessment of porosity. Initial mixtures that weigh less than 35-40 lbs. per cubic foot are adequate, and those weighing more than 40-45 lbs. per cubic foot tend to have low porosity.

F. Rate Control

Since composting is essentially a biological process, moisture, temperature, and aeration largely control of the rate of composting.

1. Moisture

The structural strength of the materials to be composted determines the upper limit for moisture content. Many materials, except woody materials, lose strength when moisture content goes above 60%. Higher moisture contents initially for paper (65%), and for tree bark, sawdust and ground wood (75-85%) will allow faster composting. Many "wet" waste like sludge, fresh animal manure, food waste, and fresh grass clippings will lose their integrity when moisture contents are above 55% which is commonly the case when received at the compost site. The site must have dry materials available to blend with these high moisture materials for successful composting. The use of an absorbent such as small grain (wheat, barley, oat or rye) straw is required and should be thoroughly mixed when high moisture wastes are composted. Therefore, successful composting will proceed when the mixture contains 55-60% moisture initially, and will be much slower when initial moisture is below 50%. Moisture becomes limiting anytime during composting that the moisture content drops below 40%. The 60% level can be checked when a handful of the initial mixture, squeezed very hard, yields a drop or two of free liquid. More than 3 or 4 drops may indicate too much moisture.

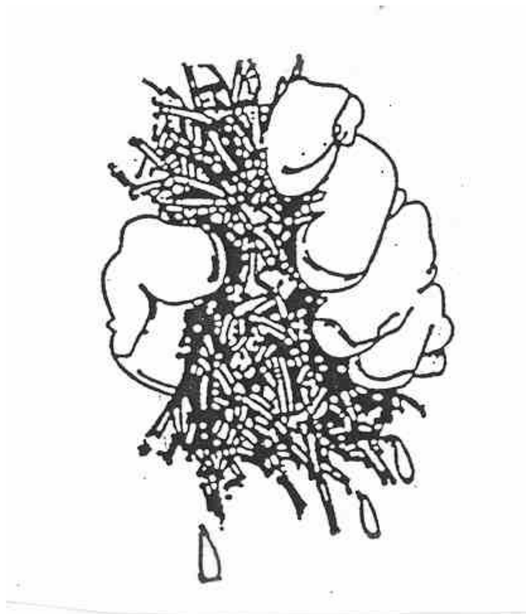

Figure 7-8 Wet Enough to Squeeze Two to Three Drops of Water

2. Temperature

Each group of microbes involved in composting has an optimum temperature range. Generally, there are three "sub-ranges" of optimum temperature of various groups of microbes.

a. Cryophilic	**(cool)**	**41 to 59^{o}F**
b. Mesophilic	**(warm)**	**59 to 113^{o}F**
c. Thermophilic	**(hot)**	**113-158^{o}F**

Most successful composting is conducted in the thermophilic range although soon after turning the temperature may go down into the mesophilic range. Composting in the thermophilic range leads to faster decomposition, and killing of pathogens and any weed seeds. Pathogen reduction is why most composting involves the higher temperature range. This temperature range is not maintained throughout the entire mass of composting material as the outside edge of the material serves as an insulator to the warmer interior. This outside material must be mixed into the composting material during turning.

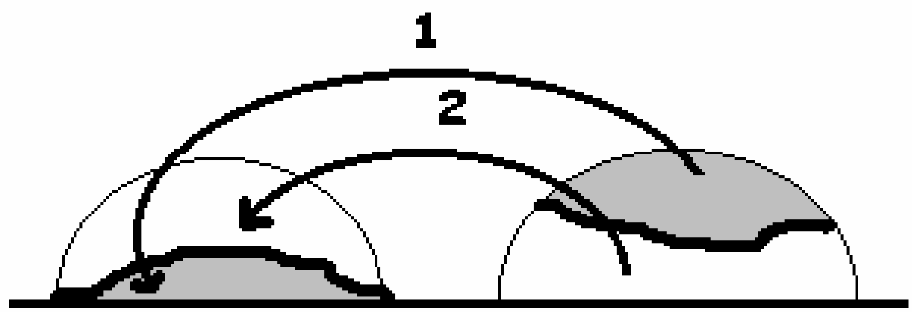

Figure 7-9 Turning to Maintain Temperature and Aeration (1.Top to Bottom, 2. Bottom to Top)

Turning is required, not only for aeration and mixing, but also to allow the heat from the interior to escape. Composting does become less efficient when the temperature exceeds 140°F. However, regulations related to composting of sludge and septage require maintaining temperatures up to 131°F (55°C) for specified periods.

One must also recognize that after the mixture is turned 2 or 3 times the maximum temperature reached in the interior is lower than the previous maximum. The compost should be reaching a stable condition when the maximum temperature of the interior reaches a point this is no more than 10°F above the prevailing average daily air temperature.

The temperature should be checked no less than daily after the mixture first begins composting. The measuring device should be long enough to reach into the interior of the mass being measured, and records should be kept of the temperature readings. These readings should be compared to previous readings.

If the temperatures during early composting stabilize below thermophilic range or decrease from the previous reading, it generally indicates that the material may be going anaerobic (oxygen deficient) and may need immediate turning for adequate aeration. In addition, it may be necessary with mixtures of materials with widely differing sizes or moisture contents to measure the temperature in layers from the outside to the interior.

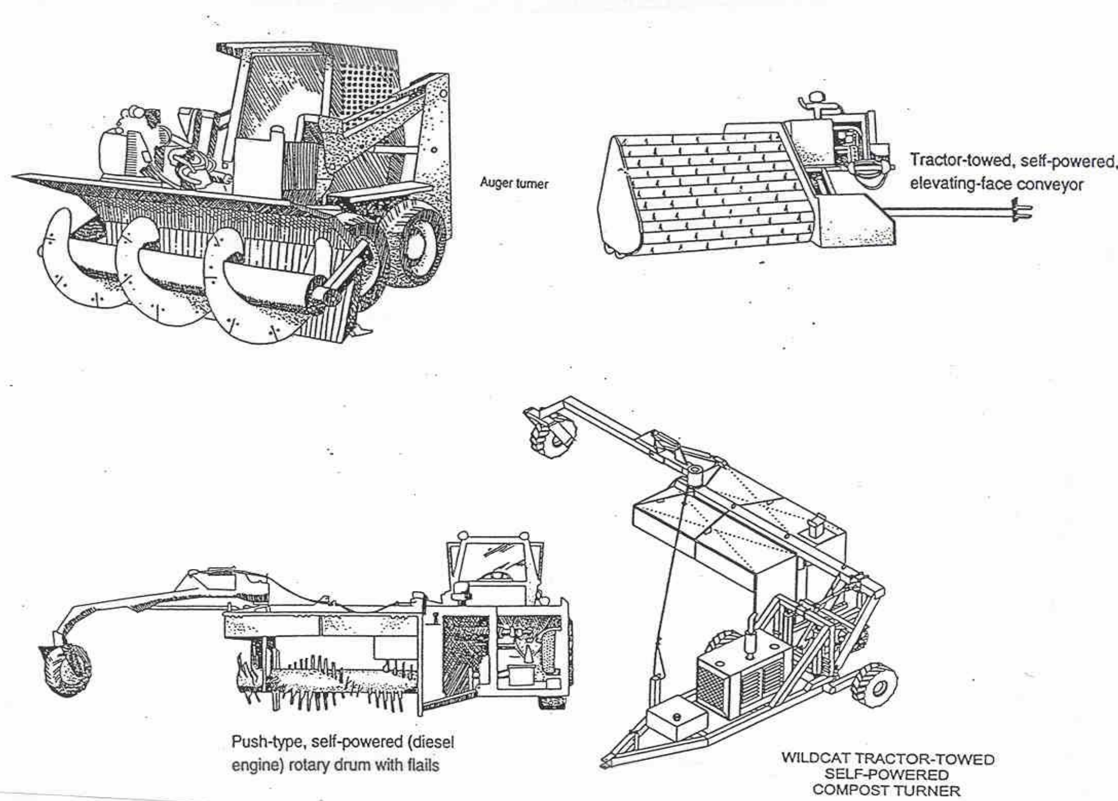

Figure 7-10 Windrow Turners.
Auger turner adapted with permission from Brown Bear Corporation.
Tractor-towed/push turners adapted with permission from Wildcat Manufacturing.

3. Aeration

Commercial composting is conducted aerobically meaning oxygen from the air is used by the microbes to decompose the materials. Air contains about 21% oxygen and microbes need at least 5% oxygen in the thin films around them to remain active. When oxygen levels go below 5%, the oxygen-requiring microbes shut down and other microbes not requiring oxygen (anaerobes) begin to multiply. This group of microbes produces volatile compounds that have a high odor and the temperature of the interior immediately decreases to the mesophilic range. When spaces between the particles are interconnected all the way to the interior, adequate oxygen will passively move from the outside air to the interior.

As mentioned earlier, excessive moisture can fill the spaces between particles reducing passive air movement. This is more critical when "wet" materials are not thoroughly mixed before initial composting or during the turning process. In these instances, more frequent turning may be necessary early in the process to allow some evaporation of excess moisture and good aeration of the mixture.

Windrow composting often produces a distinct layer just outside the hot interior where fungi rapidly grow and fill the spaces between particles. This "plugging" of spaces does lead to restriction of airflow to the interior. This is one of the reasons that composting materials at the beginning of the process, may need to be turned more regularly. However, a lack of achieving any specified temperatures with some materials may require re-examining windrow construction or materials going into the mixture in order to achieve required temperatures for pathogen reduction.

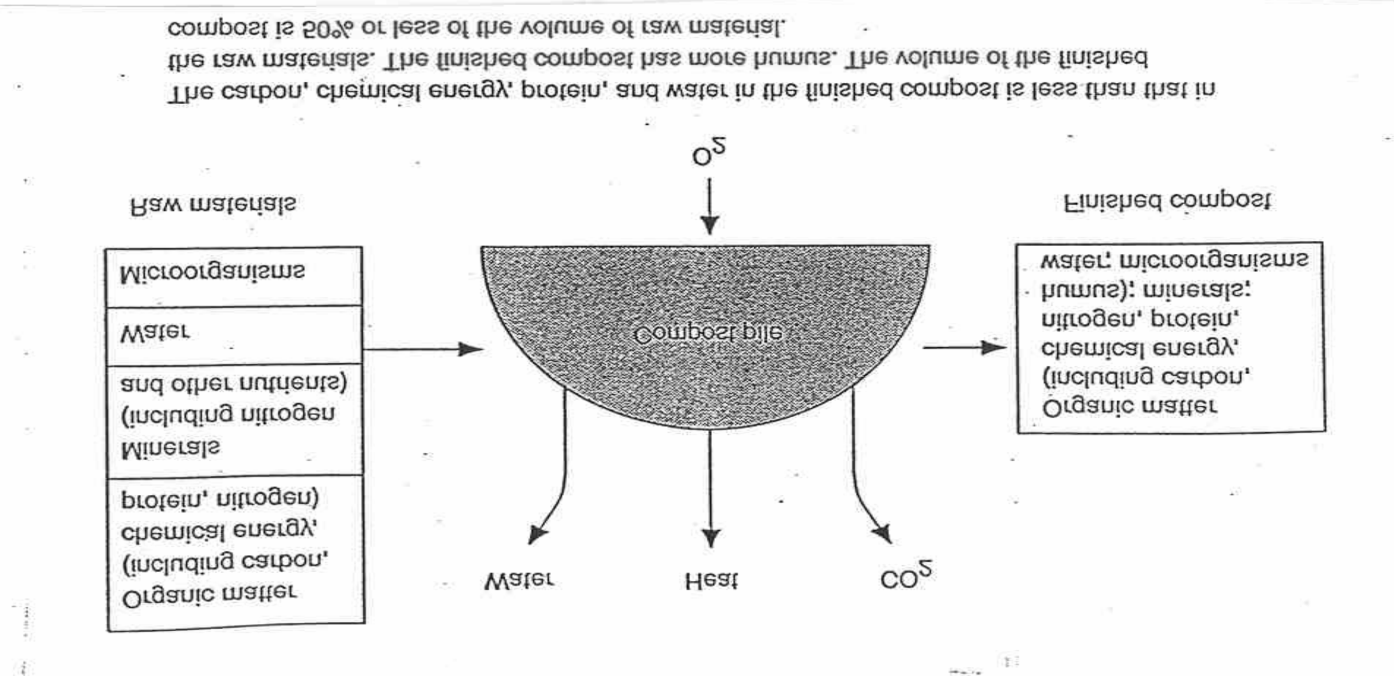

Figure 7-11 The Composting Process
Adapted with permission from On-farm Composting Handbook, NRACS.

G. Composting Sludge (or Septage)

Composting sludge or septage prior to land application will satisfy requirements of a Process to Further Reduce Pathogens (PFRP) under Section 503(b) of the federal Clean Water Act of 1972. When the primary objective is pathogen reduction, there are more specific requirements related to temperature, time, and turning frequency.

1. Mixing

Sludge for composting has usually been dewatered to achieve a solids content ranging from 20 to 25%. This level of moisture (75-80%) exceeds that desirable for composting requiring drier materials to be mixed with the sludge to lower the total moisture to 60% or slightly less. Also, sludge is usually made up of small particles and has a low C:N ratio (usually less than 20:1).

Different types of final sludge treatment influence selection characteristics of other materials for composting. Aerobically digested sludge has a higher level of volatile compounds that indicate a higher potential energy level. This allows for the rapid achievement of thermophilic range temperatures during composting. Anaerobically digested sludge tends to have lower levels of volatile compounds (and lower odor during composting and curing) that benefit from combining with a material of high available energy to more quickly achieves high temperatures. If a high-energy material (straw, leaves, etc.) is not available, it will take longer for the composting materials to reach desired temperatures.

When composting sludge alone, a bulking agent of dry chipped wood (1/2 to 1 inch) should be added to increase the C:N ratio. This will also lower the moisture level, by serving as a moisture absorbent, and increase large pores for adequate passive oxygen movement into the mixture. Dry leaves may also serve as an absorbent, help lower moisture content, and increase the C:N ratio, but provide only minimum help for increasing large pores.

Septage is a low solids containing material removed by pumpers from septic tanks used by homeowners and small businesses. Septage has a low C:N ratio and can serve as a moisture source for drier materials. Since this material is a product of anaerobic digestion, it can be quite odorous. Septage can be spread over the windrow or in-vessel row and immediately mixed into the other materials to minimize odors. It is generally not suitable to be used in this manner with static pile composting unless it is premixed into the materials before forming the static piles. Odor will be more of a problem when using blowers as opposed to vacuum type systems where the odor can be trapped or further treated in bio-filters.

2. Temperature

When using sludge or septage as a portion of the mixture for composting, the temperature must be maintained at 55°C (131°F) for 3 days when composting with the in-vessel or static pile system. With the windrow method, the sludge or septage containing mixture is to be maintained at 55°C (131°F) or higher for 15 days or longer, and there shall be a minimum of 5 turnings of the windrow during this period. Achieving and maintaining these temperatures will require careful monitoring and recordkeeping of the composting material. The turning will accomplish mixing of the outer layer into the mixture for more complete composting and pathogen reduction. This allows the entire mixture to reach the necessary temperatures during the specified length of time.

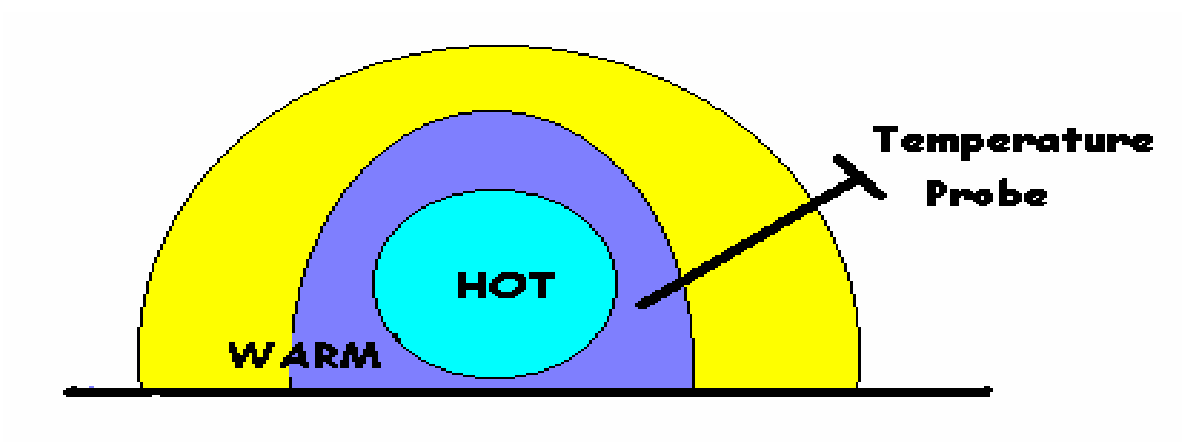

Figure 7-12 Windrow Temperature Profile

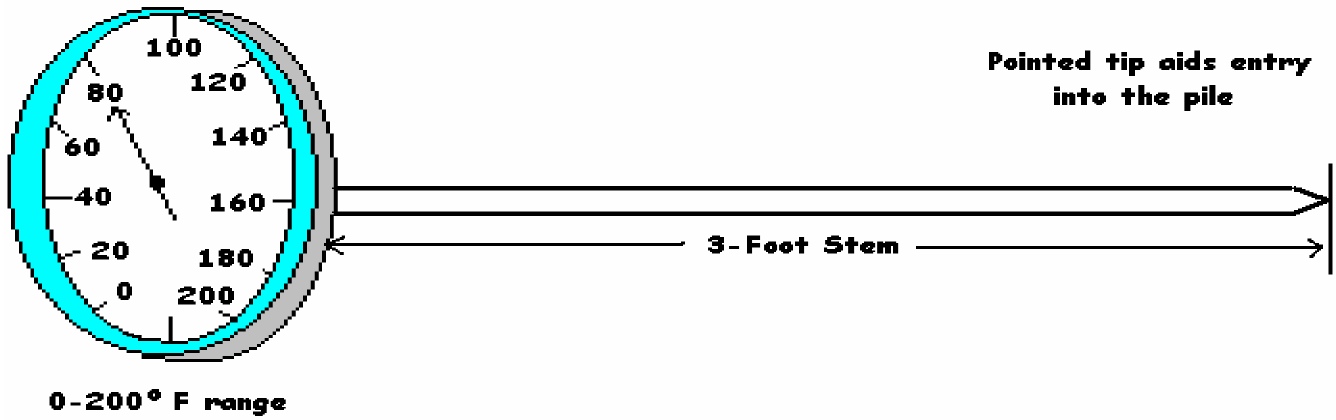

Figure 7-13 Compost Thermometer

A commercial thermometer with a 3 to 4 ft probe is necessary to measure temperature. By keeping careful records, the operator can optimize turning as temperatures rise above those required, and greatly accelerate pathogen reduction and composting. When the temperature reaches the 150 to 155°F, turning should follow quickly to avoid potential spontaneous combustion.

As the composting nears completion, less heat may be developed after each turning. If temperatures of 140°F or above are no longer reached, this may be an indication that this type of compost is stabilizing and approaching the time for moving to the marketing area.

3. Aeration

Aeration during composting of mixtures containing sludge or septage serves three main purposes:

a. Source of oxygen
b. Temperature control
c. Moisture removal

Use of bulking agents and thorough mixing will increase the movement of oxygen into the materials. With the initial high moisture content of sludge and fine particle size, resistance to airflow can be reduced by having 10 to 15% of the material as bulking agent. Subsequent mixing during turning of the composting material exposes fresh surfaces, speeds up the release of moisture, and re-establishes pore space.

4. Curing and Screening

Curing of compost containing sludge or septage is a vital part of the whole process. The curing area should be located where the materials can be mixed from time to time to maintain aeration if not immediately marketed. In addition, the curing area should allow separation of compost lots for isolation to wait for any required pathogen or chemical analysis.

Prior to marketing, screening of the compost is usually necessary to remove larger particles of bulking agents for a uniform product and to remove any unsightly items. Most compost users prefer not to have large particles or plastics showing in the purchased compost. The larger particles of bulking agent can be recycled into the next mixture for composting. The screen size will be somewhat affected by market demands. A ½ inch screen is suitable for most composting markets.

In most cases, stationary screen systems are not suitable for screening sludge compost. Some type of rotating drum system is more desirable as the mechanical action will more clearly separate the finer sludge from the bulking agent.

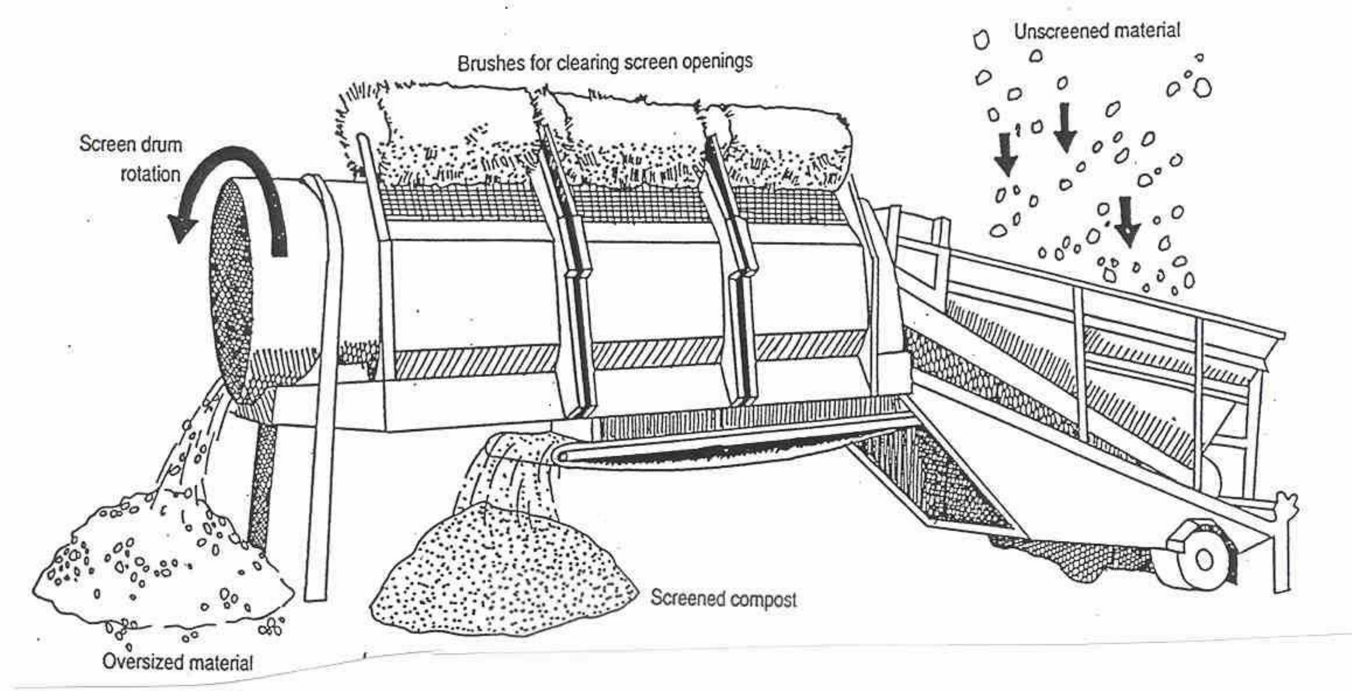

Figure 7-14 Trommel Screen
Adapted with permission from On-farm Composting Handbook, NRACS.

H. Screening

Prior to marketing, screening of the compost may be necessary to produce a more desirable looking product. When composting leaves, screening is normally not necessary, as grinding followed by composting will produce a very homogeneous material.

Some communities have found that it is desirable to use a bulking material such as chipped or ground wood in their composting operations. This material, being high in carbon, may reduce the potential of odor from materials with a high nitrogen content and provide space for more air in the compost. The woody material will decompose much slower and will require screening out prior to marketing. Materials removed through screening may be returned to the system for regrinding and composting. As stated previously, the size of the screen will be determined by market demand. A ½ inch screen is used by many compost operations.

A custom operated screening service may be the most economical approach unless the composting site has a very large volume. Availability of custom services, volume of operation, intended market, and an economic analysis may be necessary to determine the best solution to screening needs.

Study Questions – Section 7

1. The composting method best suited to a community will be determined by :

   a. ___________________________________

   b. ___________________________________

   c. ___________________________________

   d. ___________________________________

2. Name three collection systems for yard waste:

   a. ____________________________________

   b. ____________________________________

   c. ____________________________________

3. Windrows or piles should be positioned on the site slope ___________________ to the natural flow of the water to prevent ponding.

4. Ponding may also cause ______________ ________________ with mud holes developing in the ponded areas.

5. ___________________ greatly enhances the speed of decomposition and produces a more uniform and desirable end product.

6. A windrow is an elongated compost pile usually ______ to ______ feet high and up to ________________ of feet long.

7. The distance between windrows needs to be wide enough to allow for

   ____.

8. What four things allow the composting process to proceed more rapidly?

    a. ____________________________________

    b. ____________________________________

    c. ____________________________________

    d. ____________________________________

9. Excessive moisture levels in compost leads to anaerobic conditions which cause the materials to become more acid and cause ____________________.

10. __________________ ___________________ in compost is the single best indicator of the rate of composting.

11. Turning windrows allows _____________ to escape and _________________ levels to increase.

12. Composted sludge must meet the requirements of a process to further reduce ___________________________.

Section VIII - Monitoring and Recordkeeping

It is essential that a composting site keep accurate records of the receipt and disposal of all materials. In addition, records need to be kept on processing activities relating to the materials. This will include information on: types (and perhaps analysis) of material received, dates of grinding and mixing operations, dates for formation and turning of windrows, and daily temperatures of composting materials as designated by 401 KAR 45:100 and 401 KAR 48:200. General daily weather observations (sunny, overcast, wind speed, wind direction, etc.), high and low temperature, and precipitation amounts should be recorded. Problems such as odors, runoff, dust, etc. should also be recorded. Documentation of all these items will assist in changing management that will help prevent the reoccurrence of any problems.

A. Solid Waste Composting Facilities

The Division requires solid waste composting facilities to provide quarterly and yearly monitoring reports. These reports must provide information on the amount, sources, and types of materials received. The records of the amount and time the materials spent in the active compost process, and the names and addresses of recipients of 20 cubic yards or more of compost. A representative sample of the compost must be analyzed at least once per year in accordance with 401 KAR 48:200 Section 3(5) and your registration.

B. Special Waste Composting Facilities

Wastewater sludge composting requires monitoring to show the composted materials have met the process time and temperatures specified for a Process to Further Reduce Pathogens (401 KAR 45:100 Section 12). To comply with the federal sludge rule (40 CFR 503) compost must be analyzed for ten pollutants, six of which are already required by state regulation, vector attraction reduction, and pathogenic organisms. To meet both the state and federal compost quality monitoring requirements, a representative sample of the compost must be analyzed for the parameters listed in 401 KAR 45:100 Section 6 (20)(b) plus total arsenic, mercury, molybdenum, and selenium, and the density of fecal coliform or *Salmonella* bacteria. Samples must be collected and analyzed at least twice per year, and up to twelve times per year, depending on the volume of sludge or size of the wastewater treatment plant.

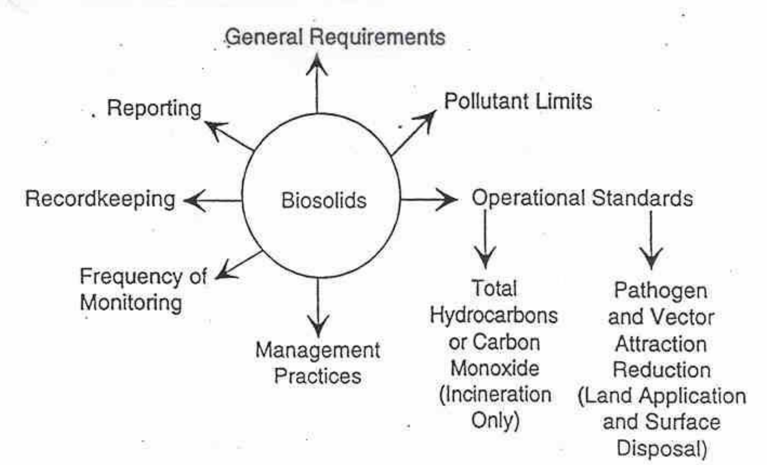

Figure 8-1 What the Part 503 Standards Include
Adapted from A Plain English Guide to the EPA Part 503 Biosolids Rule EPA/832/R-93/003 September 1994

Study Questions – Section 8

1. It is essential for a compost site to keep accurate records. List the information that must be recorded.

a. Solid waste composting facilities

   i. ______________________________

   ii. ______________________________

   iii. ______________________________

   iv. ______________________________

   v. ______________________________

   vi. ______________________________

b. Special waste composting facilities

   i. ______________________________

   ii. ______________________________

   iii. ______________________________

   iv. ______________________________

   v. ______________________________

   vi. ______________________________

Section IX - Marketing Compost

Before designing a composting project, it is important to first develop a marketing strategy for the end product. The regulations state that 75% of the finished product must be distributed or disposed of within one year of completion of curing (401 KAR 48:200 and 401 KAR 45:100). Some communities give the compost to local residents as a method of distribution as well as a form of public relations for the composting project. Other communities choose to assign a value to it and charge a minimum fee of $3 to $10 or more per cubic yard. There may be some psychological advantages to assigning a value to the compost making it a "valued" product.

With the increasing costs of landfill tipping and laws and regulations prohibiting disposal of yard waste in landfills, opportunities have developed for private sector involvement in composting projects. If composting is to become a viable economic venture, the compost operator may need to be paid for receiving the waste and be able to charge for the end product. Free distribution of compost by municipalities may actually hinder the development of this entrepreneurship while reducing recovery of total waste management costs.

If a viable market for the compost is to be developed, it will be necessary to produce a homogeneous product with consistent quality. The compost must be free of foreign material such as glass and plastic. In addition, the product must have been composted long enough so it is truly a compost and not just ground waste. This is particularly important if the compost is to be worked into the soil rather than used as surface mulch.

A. Uses of Compost

By definition, compost is not considered a fertilizer. Compost, when mixed with the soil, increases the water holding capacity of soils and makes soils easier to cultivate. It also helps reduce erosion. Soils in many areas of Kentucky have rather high clay content. Although clay has good water holding capacity, the infiltration rate for clay is very slow. The incorporation of compost into clay soils will greatly increase this infiltration rate and reduce runoff.

Potential Compost Users

Bulk Users	Retail/Wholesale
Land reclamation	Garden centers
Landfill cover	Home gardeners
Parks	Topsoil
Highway maintenance	
Cemeteries	
Schools	
Nurseries	
Greenhouses	
Sod farmers	
Golf courses	
Lawn care	
Landscape contractors	
Industrial park grounds	

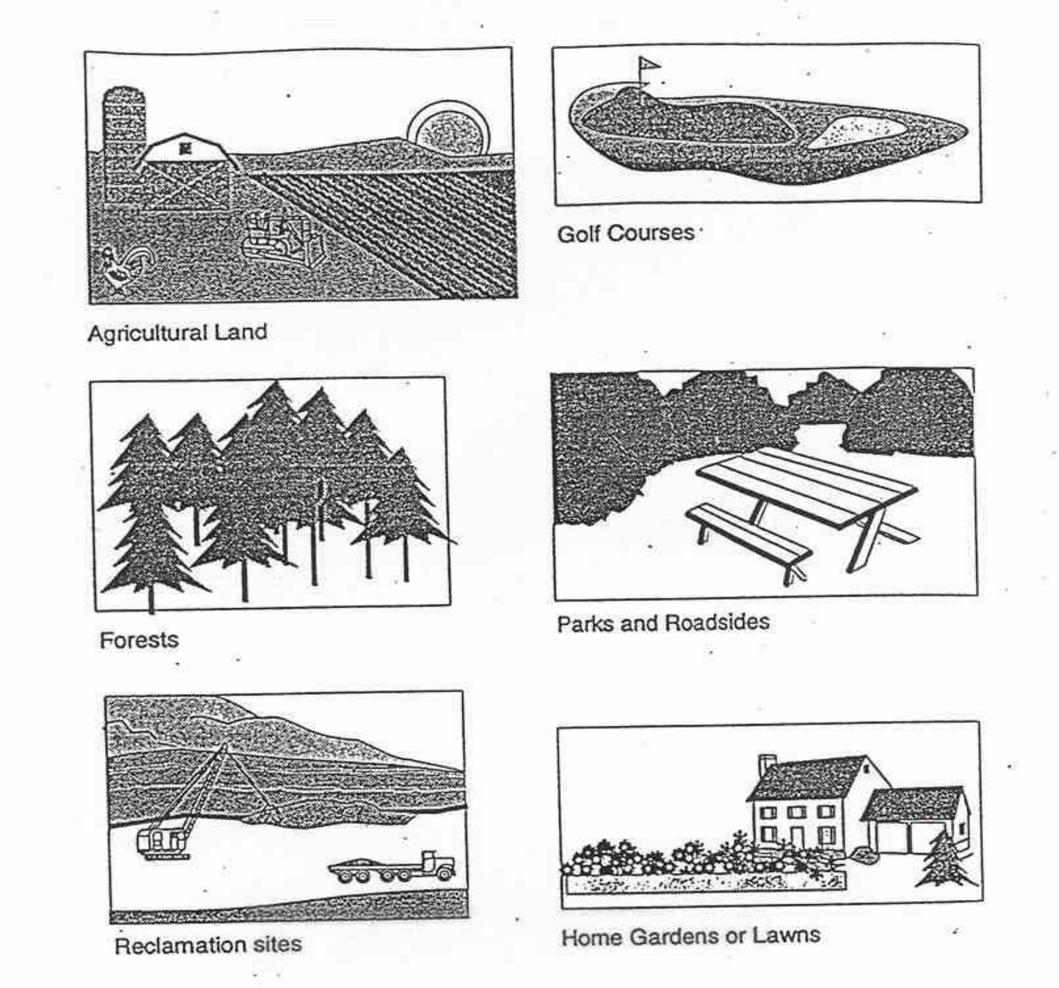

Figure 9-1 Compost can be beneficially applied to agriculture land, forest land, reclamation sites, golf courses, public parks, roadsides, plant nurseries, and lawns and home gardens. Adapted from A Plain English Guide to the EPA Part 503 Biosolids Rule EPA/832/R-93/003 September 1994

B. Lawn and Garden Use

The use of compost in lawns and gardens has been one of the most important markets for compost. It is commonly used for incorporation into the soil as well as surface mulch to reduce weed growth, evaporation, and water runoff.

The demand for compost has a potential for a significant increase, as peat moss becomes less available and more costly due to restrictions of peat moss production through environmental concerns. At least one major lawn and garden supply company is developing compost sites throughout the nation to replace peat moss with compost.

C. Municipalities

Many communities use large quantities of compost in municipal facilities such as golf courses, parks, flower gardens, and landfill cover. In addition, some state, county, and local governments require contractors to use compost in reseeding roadsides and construction sites. Municipal use of compost can provide a good demonstration to the public on the value of compost. In addition, municipalities may determine that composting is an important process that will reduce total waste management costs for taxpayers.

D. Agricultural Application

For centuries, farmers have known the value of returning livestock manure and crop residues to the soil. Compost added to farmland would have much the same value as crop residues. Unfortunately, the bulk and relatively low value of compost does not normally justify the expense of purchasing, transporting, spreading, and incorporating compost onto farmland. While farmland can always be considered as an option for compost use, it does not provide an economic incentive for composting until large quantities of compost are available that cannot be marketed through other uses.

Study Questions – Section 9

1. Regulations state that _________ of the finished compost product must be distributed or disposed of within one year of completion of curing.
2. To develop a good compost product, it will be necessary to develop a _______________ _________________ with ____________________ ___________________.
3. Unless certified by chemical analysis and registered as such compost is not considered a ___________ ______________ or _________________ by Kentucky regulation.
4. ______________________ ___________________________ ___________________ is the best solution to water runoff and erosion.

Section X - Trouble Shooting

Every composting site will develop some problems. However, most of these can be avoided with proper facility site selection, design, operation, maintenance, and good management practices. Unfortunately, many problems will get worse over time if no corrective measures are taken. Therefore, early detection and correction are important. Some of the more common problems associated with compost sites are as follows:

A. Odors

Undesirable odors are the most common and serious problem of composting. Odors may arise from content of the materials received, handling of the materials after receiving, and management practices followed during composting. If materials with a high potential odor are likely to be stored and handled at the site, it is important to isolate the site from residences and to maintain wide buffers of trees and shrubs on the site.

Some materials hauled to the site may have been exposed to previous processes that tend to generate a high level of volatile compounds or odors. Alternatively, materials may have been mishandled to allow some decomposition that gives off odors. Some odors can be generated from improper handling or storage of the materials after they arrive at the compost site. If materials are stored outside and allowed to become wet, they can start to heat up or go anaerobic before being placed into the actual composting process. The site can overcome many of these problems by allowing only certain materials to be received at the site, or by being able to handle a variety of materials once they are received. For example, fresh grass clippings need to be incorporated or spread out and dried to avoid rapid decomposition and to keep them from going anaerobic. The latter will usually require more knowledge, space, equipment, and personnel for handling materials. This is why many composting sites have restrictions on what materials are composted.

It is important to understand the composting process in order to minimize potential odors at the site. In general, the site manager and personnel should focus on such factors as temperature, aeration, and moisture in maintaining good management practices. Scheduling turning to take advantage of favorable wind direction, when possible, may help in reducing odor complaints. Turning compost during the middle of a weekday, when nearby residents are inside or at work, may help as opposed to turning on Saturday or Sunday. Turning close to evening, when air tends to be moister and moves to lower areas of the landscape, will trap and move the odor causing more complaints.

Balancing the C:N ratio of the materials will help speed the process. Bringing in materials such as animal manure, sludge or septage to supply more N for high C materials may be needed and done at a low cost. However, there should be a plan for immediate handling after they arrive on site.

Several chemicals have been evaluated to help reduce odors. Usually these need to be applied at the time of storage and after each turning of the compost. These multiple applications can add significant cost to the operation.

B. Run-on and Run-off

Proper site selection is by far the best solution to controlling water run-on and run-off. The site should be designed in such a manner that no outside water flows onto the site. Terraces or berms may be constructed to divert water around the site. Such terraces or berms need to have gently sloping banks so they can be seeded with grass and mowed easily with large equipment. It is important to keep the site attractive.

Runoff from a site may need to be collected in a specially designed and constructed catchment basin. This water should not be allowed to enter streams, wells, or sinkholes. Water from a compost site has the potential to contain high levels of suspended solids, be significantly low in dissolved oxygen, and have a high biochemical oxygen demand (BOD) due to the high organic content of the water. The combination of high suspended solids, low dissolved oxygen, and high BOD may adversely impact streams, ponds, and lakes resulting in the death of fish and other aquatic life. Therefore, some form of containment is often necessary (check permit requirements for details). The construction of terrace channels, holding ponds, or catchment basins to control runoff may satisfy this requirement. The USDA Natural Resources Conservation Service can help in construction design specifications. Terrace channels and pond banks should be constructed to facilitate mowing and maintenance. The use of 50-75 foot vegetative buffer strips above the channels and holding ponds will act as a filter to remove most suspended solids and nutrients. Proper control of suspended solids and nutrients will prevent silting in the holding pond and help control eutrophication (aquatic plant growth) of the pond and downstream receiving waters. Water collected in the holding ponds may be allowed to evaporate or be recycled back into the composting process. If the water is to be discharged into a receiving stream, a Kentucky Pollution Discharge Elimination System Permit (KPDES) from the Kentucky Division of Water KPDES Branch may be required. If the construction of terraces, berms, or ponds take place in or near the floodplain, prior permission from the Kentucky Division of Water Floodplain Management Section will be required.

C. Erosion

Surface erosion is best controlled by proper site selection. Sites should be selected with a 1-3% slope (1 to 3 feet drop per 100-ft. horizontal distance) to facilitate controlled drainage. While it will not be possible to maintain vegetative cover on the working area, a well-established vegetated buffer should be established around the perimeter of the site. It is essential that no off-site water be allowed to flow onto the site. In seasons where no composting activity is taking place, compost can be used as surface cover to restrict surface water flow and help reduce erosion.

D. Temperature

There are several possible causes for low temperatures. First, the oxygen level may be too low. Turning and aeration should correct this. Another potential for low process temperatures is that the moisture level may be too low for microorganism growth. This will require additional water to be added. Excessive moisture may also cause low process temperature due to anaerobic conditions. Turning the materials may be required to allow the excess water to be evaporated, or it may be necessary to add a bulking agent with a larger particle size. If piles are too small, not enough insulation is provide to maintain internal heat. In such a situation, combining two or more piles or windrows may be the answer.

If the material being composted has a high C:N ratio, not enough nitrogen is present for good microbe development. In this case, additional nitrogen needs to be added to re-establish microbe growth and heat development.

If the process temperature rises above 140°F, the most common method to reduce the temperature is to turn or mix the materials. This allows the heat to escape and cooler air to enter. In static systems, the air circulation may need to be reversed. Optimum sizing of piles, windrows, static systems, etc. will vary with the materials involved, the stage of decomposition, and the season of the year. Specific temperature requirements for meeting the Process to Further Reduce Pathogens (PFRP) in septage and biosolids are contained in 401 KAR 45:100 (Section 12) and 40 CFR 503, Appendix B.

E. Blowing of Materials

Wind blowing most yard waste is normally a minor problem. Even leaves delivered to a compost site tend to stay in one place quite well. Once material has been ground and mixed, it is even more stable.

Paper is more prone to movement by wind and may develop into somewhat of an eyesore if not handled correctly. It may be necessary to restrict the grinding of paper to an indoor site, grind only on windless days, or mix with materials that have a very high moisture content.

F. Dust

Dust may become a problem from two sources: trucks creating dust as they travel the roads leading to the site, and dust developed at the site during composting activities. Dust from the roads can be best corrected by providing improved surfaces. It is important that traffic be able to enter and exit the site during all types of weather. Blacktop, asphalt, or a densely compacted surface is essential. Sprinkler trucks may be needed to control dust during periods of heavy traffic flow or on dirt and gravel roads.

Dust from the operation may arise if the materials are allowed to dry below the recommended moisture concentrations. It is essential to have water available to add to the compost and wet the working area. It may also be necessary to restrict operations due to windy conditions. Proper site section will also help control and prevent dust problems.

G. Fire

As with dust, the danger of fire is greatly reduced if the materials received at the compost site are high in moisture content. Temperatures reached during the composting process are not adequate to produce spontaneous combustion if the proper moisture content and management practices are followed. Even after taking these precautions, steps must be taken to prepare for the possibility of fire. All transportation and process equipment should be equipped with fire extinguishers. A water source should be available for fire suppression. Communication by telephone or radio to the local fire service is a necessity. It is also recommended that the local fire service visit the facility to become familiar with the layout of the operation. Proper maintenance of equipment, including frequent removal of leaves and debris from engines and exhaust systems, will also greatly reduce the possibility of fire. Maintaining proper distances between windrows will allow for operation of equipment to isolate hot spots in case of fire. Additionally, a no smoking policy, access control to prevent vandalism, and keeping the buffer zones and perimeters well mowed will reduce the potential of fire.

H. Vectors

Vectors around a compost site are seldom a problem if proper management is maintained. Some materials such as food waste, animal manures, and wastewater biosolids may require additional care to control vectors such as insects and rodents. Immediate incorporation of these materials or covering the materials with sawdust or mature compost will help reduce problems. Materials not suitable for composting should be separated and disposed of immediately to reduce habitat and food for rodents and insects.

Limiting standing water from the site will control the breeding of mosquitoes and transmission of the diseases they carry. Removal and proper disposal of old tires, barrels, and other containers will further eliminate mosquitoes breeding habitats. Attention must also be given to catch basins and holding ponds. The use of natural control systems, such as frogs and fish or commercially available environmental friendly pesticides in water catchments, may help in controlling mosquitoes. If the water will be re-circulated into the composting system, always make sure the pesticides will not harm the compost microbial population and will maintain no residual in the final product.

I. Noise

The noise created by heavy trucks, loaders, and other large equipment can become a significant problem if the composting site is improperly located. Screening the site with trees will absorb much of the sound. All equipment should be kept in good working condition with mufflers in place. Timing operations to avoid early morning, late evening, and weekend operations may help reduce complaints. All operators and other employees should be provided with appropriate hearing protection devices. A very common complaint by neighbors is about the incessant "backup warning beeps" of loaders and other equipment.

Study Questions – Section 10

1. List five potential problems associated with compost facilities.

   a. ____

   b. ____

   c. ____

   d. ____

   e. ____

2. ____________, _____________, and _______________ are management factors that need to be controlled to avoid odors.

3. Run-off water has the potential to contain high levels of ___________ and ___________.

4. Failure to achieve desired temperatures may be the result of _____________, ______________, ________________, ________________ or _____________.

5. An organism capable of spreading disease is called a _____________________.

Section XI - SAFETY

Safe operation of composting activities is only possible with the complete cooperation of all personnel participating in the operation. This cooperation will only be achieved if there is a mutual trust and respect between members of management and labor. Concern for the welfare of all employees must be evident to maintain a safe workplace. A safe workplace does not mean a workplace free of all risks. It does mean a workplace where every attempt is made, by all involved, to recognize and minimize hazards and to train each employee in the proper procedures to manage those hazards.

Composting operations will involve certain risks because of the potential for encounters with heavy equipment used in processing, transportation hazards during collection, foreign materials contained in raw materials, vectors, pathogens, noise, dust, fire, etc. Composting activities will involve risk, but those risks do not need to be unreasonable. Fairness to workers require that a thorough understanding of the risks and hazards present be conveyed to them and that workers receive training to deal with potential hazards.

The economic impacts of unsafe operations cannot be ignored. The direct cost of treatment for injuries or disabilities, employee death, increased insurance cost, equipment and facility damage, as well as the damage to worker morale and productivity will negatively impact the success of the operation. The effects of accidents and unprotected exposure to occupational hazards can and will overwhelm operational budgets.

In addition to fairness and economic concerns, safety on the worksite is mandated by U.S. Occupational Safety and Health Administration regulations. The regulations contained in 29 CFR Part 1910 have been adopted by the Kentucky Occupational Safety and Health Standards Board as 803 KAR 2:300 through 2:320. OSHA regulations require employers to make employees aware of hazards they face in the workplace. Additionally, they must be trained to respond to those hazards in a safe manner. While it is not in the scope of this manual to address all regulatory requirements, we will consider some of the basics.

A. Compost Operation Safety Programs

The day-to-day operations at a composting facility can be developed by evaluating the hazards encountered in the normal workday, developing procedures to reduce those hazards, and implementing those procedures through a comprehensive safety program. We can generally divide associated hazards into three broad categories; these are chemical, physical and biological. We will examine the chemical hazard first.

1. Chemical Safety

a. Employee Right to Know (29 CFR 1910.1200)

The first step in developing a safety program is to identify all chemical hazards and to ensure that all employees are informed. This means that employees have the right to know the identity of all hazardous chemicals they will encounter in the workplace, understand the health effects of exposure, and know and understand how to work safely with those materials. This information must be provided in writing. Generally, there are not a great number of hazardous chemicals or materials on a composting site. However, a survey and inventory should be conducted to assure the proper Materials Safety Data Sheets are available.

The Employee Right to Know Program must include the following elements:

1. All hazardous materials in the workplace must be identified.
2. Material Safety Data Sheets (MSDS) on all identified hazardous chemicals must be prepared and placed in a notebook accessible to all employees at the site.
3. Employees must be trained on the requirements of Right–to-Know legislation, the content and purpose of MSDS, and how to access all information related to the workplace.
4. All containers at the worksite must be appropriately labeled to describe contents and have appropriate hazard warnings.
5. Employees must be trained in how to handle and manage the hazards to which they could be exposed.

b. Material Safety Data Sheet (29 CFR 1910.1200)

Materials Safety Data Sheets shall be in English, available for all hazardous materials on site and shall contain the following information:

1. The chemical manufacture's name, address and emergency telephone number, the chemical name, trade name, and chemical formula.
2. The physical and chemical characteristics of the hazardous chemical (such as vapor pressure, flash point).
3. The physical hazards of the hazardous chemical, including the potential for fire, explosion, and reactivity.

4. The health hazards of the hazardous chemical, including signs and symptoms of exposure, and any medical conditions which are generally recognized as being aggravated by exposure to the chemical.
5. The primary route(s) of entry.
6. The OSHA permissible exposure limit, ACGIH Threshold Limit Value, and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the material safety data sheet, where available.
7. Whether the hazardous chemical is listed in the National Toxicology Program (NTP) Annual Report on Carcinogens (latest edition), or has been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest edition), or by OSHA.
8. Any generally applicable precautions for safe handling and use which are known to the chemical manufacturer, importer, or employer preparing the MSDS, including appropriate hygienic practices, protective measures during repair and maintenance of contaminated equipment, and procedures for clean-up of spills and leaks.
9. Any generally applicable control measures that are known to the chemical manufacturer, importer, or employers preparing the MSDS, such as appropriate engineering controls, work practices, or personal protective equipment.
10. Emergency and first aid procedures.
11. The date of preparation of the MSDS or the date of the last change made.

c. Protection From Chemical Hazards

Once information on the chemical hazard has been obtained, the employer and employee can select the proper personal protective equipment. Hazardous materials may enter the body by inhalation (most common), ingestion, absorption through the skin or eyes, or injection.

The primary ways workers are exposed include:

1. Failure to follow proper procedures or to use appropriate personal protective equipment.
2. Inadequate knowledge of the materials.
3. Failure to decontaminate yourself or your equipment.
4. Careless: unprotected contact with hazardous materials; walking through puddles or into clouds of unknown vapors; consuming food, water or smoking cigarettes contaminated by contact with gloves, equipment or unwashed hands.

6. Physical Hazards

Physical hazards abound at compost operations from exposure to large equipment, as well as many relatively minor injuries such as cuts, strains, sprains, bruises and abrasions. These injuries occur as a result of slips and falls, improper lifting, incautious backing of equipment, and improper use of hand or power tools. While these injuries are generally minor, serious injuries or deaths may result. Prolonged exposure to loud noises may permanently damage hearing. Exposure to heat and cold may cause heat stroke or frost-bite; and, can lead to indirect effects such as fatigue, dizziness, and confusion which in turn can lead to accidents, injuries, and death.

General guidelines for protection from physical hazards include:

1. Use proper protective equipment such as hearing protection, hardhats, steel-toed boots, safety glasses, and gloves.
2. Maintain equipment in safe working conditions: perform regular preventive maintenance on heavy equipment, replace frayed electrical cords on hand tools, replace broken handles on shovels, rakes, hammers, etc.
3. Keep guards properly adjusted and in place on rotating and moving equipment such as power takeoffs.
4. Practice good housekeeping by keeping the work area clean and free of debris and excess water.

3. Biological Hazards

Exposure to biological hazards is always a possibility. Appropriate precautions must be taken. While a yard waste facility may seem, at first glance, free from the possibility of exposure, this may not be the case. Closer examination reveals materials such as glass, metals, used needles, and other sharp objects that may offer a significant risk of puncture to the skin, thus introducing pathogenic organisms into the body. These organisms may arise from human or animal sources that have contaminated the yard waste.

Wastewater composting operations represent an additional risk as the materials are of direct human origin and very likely to contain pathogenic organisms, at large concentrations, especially during the beginning of the process.

Additionally, the process of composting may encourage the growth of a number of molds and fungi that act as allergens. There is also the possibility of exposure to blood borne pathogens from injured personnel if proper precautions are not followed.

It is important that all employees are aware of the possibility of exposure and that steps are taken to reduce risk factors. As with the risk from chemical and physical hazards, selection of the proper personal protective equipment and personal hygiene will greatly reduce the risk of biological exposure.

General guidelines for protection from biological hazards include:

1. Avoiding direct contact with suspect materials.
2. Wear latex or vinyl gloves, under work gloves, when in immediate contact with suspect materials.
3. Training for all personnel in blood borne pathogen protection.
4. Use of proper respiratory protection for personnel exposed to dust and debris in the processing of materials.
5. Employee availability to hand washing, shower and toilet facilities.

Study Questions Section 11

1. A safe work place is one where every attempt is made to _____________ and _______________ hazards and to ____________ each employee in the proper procedures to manage those hazards.
2. List three reasons for maintaining the safe operation of a composting facility.
   a. ____
   b. ____
   c. ____
3. List the three broad general hazard categories a worker at a compost facility may be exposed to:
   a. ____
   b. ____
   c. ____
4. An employee has the ________________ ____ _______________ what hazardous materials are on worksite and trained to work ____________ safely with those materials.
5. A __________ ____________ ____________ __________ must be available to the employee for all hazardous materials used or stored on site.
6. List three ways an employee can increase protection from physical hazards.
   a. ______________________________________
   b. ______________________________________
   c. ______________________________________

7. List three possible sources of biological hazards at a composting facility.

   a. ____

   b. ____

   c. ____

8. List four ways to protect yourself from exposure to biological hazards.

   a. ____

   b. ____

   c. ____

   d. ____

XII. Permitting Process

The permitting process for operation of a composting facility differs between solid waste composting facilities and special waste composting facilities. Solid waste composting facilities require a Registered Permit-by-Rule while special waste composting facilities are required to obtain a full permit.

A. Solid Waste Registered Permit-by-Rule

Solid waste composting facilities must register with the Division of Waste Management by completing and submitting form DEP 7059A, Registered Permit-by-Rule for a Solid Waste Composting Facility. At least two weeks before the completed application is submitted to the Division, the applicant must publish a notice in a daily or weekly newspaper of general circulation where the proposed facility is to be located. Once the application is received, the registration becomes effective in five business days unless it is denied. If the registration is not denied in five business days, the facility can legally operate before receiving written approval from the Division. However, if the registrant chooses to begin operation at this time, the operation must comply with the Environmental Performance Standards set forth in 401 KAR 30:031. The registrant must also ensure that the operation complies with any local land use regulations and/or zoning ordinances. For these and other reasons, registrants often prefer to wait to begin operations until the state responds to their registration with written approval. There are no permitting fees for this type of registration. A public meeting may occur if the Division receives a request for a meeting because of the public notice. Additionally, any person who feels they are aggrieved by the operation of the compost facility may petition the Cabinet to demand a hearing that could result in modification or revocation of the registration. Therefore, the applicant may want consider conducting a public meeting if it is thought that the proposed operation might be controversial to the public -- even if such a meeting is not initiated by the Division.

Once the application for a registered permit-by-rule is reviewed by the Division, and found to be complete, the registrant will be issued a registration number. Quarterly and annual reports are required to be submitted to the Division. Quarterly and annual reports must be on a form approved by the Division.

The registrant may make modifications to the approved registration, such as adding an additional source of material, by submitting a revised registration to the Division. The Division may also request modifications after approval if such modifications are determined necessary to provide adequate protection to human health and the environment.

B. Special Waste Formal Permitting Process

Special waste composting facilities must obtain a full operating permit. The facility must apply for the permit in two phases: the first phase is to complete and submit Form DEP 7021A (Notice of Intent to Apply for a Landfarming or Composting Permit); the second phase is to complete and submit form DEP 7094D (Application for a Special Waste Composting Facility Permit) and form DEP 7094J (Past Performance Information).

1. Notice of Intent

The Division will review of the Notice of Intent to Apply and notify the applicant that the facility is deemed to be either a Type A or a Type B facility. The distinction between Type A and Type B facilities is determined by the anticipated volume of waste to be processed and the concentration of parameters in the special waste to be processed.

Type A facilities have a higher concentration of "listed" parameters and volumes. These requirements are found in 401 KAR 45:100 Section 2. Type A facilities are subject to provisions for public participation during the permitting process; posting of financial assurance (for privately owned facilities only); surface and groundwater monitoring in accordance with 401 KAR 45:160; and the post-closure requirements of 401 KAR 45:100 Section 4.

Type B facilities have lower concentrations of the listed parameters and volumes. Regulatory requirements for Type B facilities are not as extensive as Type A facilities, but still require a Notice of Intent and Formal Application prior to beginning construction and/or operation.

KRS 224.50-760 requires any facility composting wastewater treatment sludge or water treatment sludge, whether Type A or Type B, to publish a public notice. KRS 224.50-760 also defines composting of wastewater or water treatment sludge as an industrial process, meaning such a facility must locate in an industrial zone. Applicants must investigate local zoning ordinances to ensure no violation will occur due to the location of the compost facility. Cities, counties, public and private schools, and special districts (as defined by KRS Chapter 65) are exempt from the industrial zoning requirement.

2. Application for a Formal Permit

When the Division completes its review of the Notice of Intent and makes a determination on the waste classification, the applicant shall then submit forms DEP 7094D and DEP 7094J. After being notified, by the Cabinet, that the application is complete, the permit applicant shall publish a public notice supplied by the Cabinet. This notice shall be published in a daily or weekly local newspaper, of major circulation, where the proposed facility is to be located. This applies to all Type A and Type B permit facilities where the special waste to be composted is water or wastewater treatment sludge.

The Cabinet now begins the technical review of the application. Upon completion of the technical review, a final determination is made by the Cabinet to issue a draft construction permit or a notice of intent to deny. Type A facility applicants will be required to publish a second public notice at this time. The particulars of the public information procedures are found in 401 KAR 45:050.

After the close of the public comment period, the Cabinet shall issue a final permit decision to issue or deny the construction permit. Once construction is completed, certification will be needed from the Division that all specifications for construction have been met. At this point, Type A privately owned facilities will be required to post financial assurance for closure as specified in 401 KAR 45:080. Publicly owned facilities will be required to submit an approved budget that demonstrates the required funds for closure have been secured. Type A facilities must also post financial assurance for post-closure. The estimates for closure and post-closure are calculated based on criteria established in 401 KAR 45:080 Sections 2 and 3. Financial assurance for closure and post-closure must be submitted to the Cabinet on approved forms.

Once financial assurance has been posted with the Cabinet and the applicant has submitted the required fees, a construction/operation permit is issued. Construction/operation permits shall be effective for a fixed term not to exceed ten years.

C. Permit Review and Renewal

The Division shall review the conditions of the permit after five years and modify the permit as necessary. An application to renew a construction and/or operation permit shall be submitted to the Division at least 180 days before expiration of the permit. Persons applying for renewal of a permit shall use form DEP 7095, Application for the Renewal of a Formal Permit.

D. Closure

After permanently ceasing to accept waste at a Type A or Type B composting facility, the closure report as specified in 401 KAR 45:100 Section 4 shall submitted to the Division.

Type A facilities shall commence a two-year post-closure monitoring and maintenance period starting the first day after the facility permanently ceases accepting waste. The owner or operator shall conduct groundwater and surface water monitoring as required by the facility's approved groundwater and surface water monitoring plan, and the terms of the operating permit. Type B facilities are not subject to the post-closure requirements.

At the conclusion of the two year post-closure period, the owner or operator shall submit a certification that post-closure is complete and that the site or facility complies with all post-closure requirements. Any environmental remediation or corrective action for groundwater contamination shall be performed by the permittee before the composting facility's post-closure is certified by the Division. Upon certification, the Division shall release the financial assurance bond.

E. Additional Permit Requirements

Other permitting standards for special waste permits include modification, suspension, revocation, and transfer of permits. Guidelines for these actions are found in 401 KAR 45:040.

Solid waste composting facilities are not subject to permit fees. Special waste composting facilities are subject to the fee schedule in 401 KAR 45:250. Kentucky Revised Statutes authorize the Cabinet to provide, by regulation, a reasonable schedule of fees for the cost of processing applications for permits, permit renewals, permit modifications, or permit transfers. These fees do not apply to publicly owned facilities.

All compost facilities are subject to the stormwater monitoring requirements of 401 KAR Chapter 5. Construction of ponds require either a KPDES (KY Pollution Discharge Elimination System) permit or a KNDOP, (KY No Discharge Operational Permit). The KY Division of Water should be contacted for information on these requirements.

Study Questions Section 12

1. Solid waste composting facilities require a registered ___________________ __________ _____________________.

2. Special waste compost facilities require a ___________________ permit.

3. Special waste composting permit consists of two phases:
   1. ____
   2. ____

4. The major difference between a Type A and Type B special waste facility is

   ____
   ____
   ____
   ____

5. Solid waste composting facilities are not subject to permit ________________.

XIII. CONTACTS FOR COMPOSTING ISSUES

The following description of the individual branches within the Division of Waste Management defines the responsibilities of each and offers the reader a contact person for various areas of assistance. The back door telephone number to reach anyone in the central office is (502) 564-2225. Our fax number is (502) 564-4049.

SOLID WASTE - (502) 564-6716

- Technical assistance on permits	Bob Bickner (ext. 627) Bobby Kenner (ext. 686) Frank Whitney (ext. 271)
- Annual review assistance	Bobby Kenner (ext. 686)
- Certification, forms, fees, bonding and reporting requirements	Derrick Gould (ext. 671)

RESOURCE CONSERVATION/LOCAL ASSISTANCE - (502) 564-6716

- County solid waste plans	Sara Evans (ext. 233)
- Market information	Dara Carlisle (ext. 261) Rich Green (ext. 623)

PROGRAM PLANNING AND ADMINISTRATION - (502) 564-6716

- Regulations	Nini Hughes (ext. 628)
- Open records requests	Maria Wood (ext. 636)

(Fax #: (502) 564-9232

FIELD OPERATIONS - (502) 564-6716

- Complaints	Linda Howard (ext. 680)
- Facility inspections	Bill Burger (ext. 150)

ENFORCEMENT - (502) 564-6716

- Enforcement Actions	Connie Smith (ext. 218)

KPDES, KNDOP, & Stormwater Discharge Permits - (502) 564-3410

- Surface waste run-off and pond construction	Bruce Scott (ext.437)
-Floodplain Management Section	Ron Dudda (ext.162)

Division of Waste Management Field Offices

FIELD OFFICES	PHONE NUMBER	OFFICE SUPERVISOR
- Bowling Green	(270) 746-7475	Robbie McGuffey
- Columbia	(270) 384-4735	Kerry McDaniel
- Florence	(859) 525-4923	Debby Angel
- Frankfort	(502) 564-3358	Sam Lofton
- Hazard	(606) 435-6022	Rebecca Noble
- London	(606) 878-0157	Kerry McDaniel
- Louisville	(502) 425-4543	Keith Sims
- Madisonville	(270) 824-7532	Bill Bowen
- Morehead	(606) 784-6635	Karen Glancy
- Paducah	(270) 898-8495	Marjorie Williams

Glossary

AERATED PILE COMPOSTING: See Static Pile Composting

AEROBIC COMPOSTING: Decomposition of organic materials by microbes in the presence of oxygen.

ANAEROBIC DIGESTION: Decomposition of organic materials by microbes in the absence of oxygen.

BUFFER ZONE: Area of land between the composting facility and homes or other sensitive land uses, which shields these adjoining uses from the impact of the operation. The buffer zone should include vegetation.

COMMERCIAL SOLID WASTE: All types of solid waste generated by stores, offices, restaurants, warehouses, and other service and non-manufacturing activities, excluding household and industrial solid waste.

COMPACTION: Compressing of waste to reduce its volume. Compaction allows for transport that is more efficient.

COMPOST: Materials resulting from biological decomposition of organic waste.

COMPOSTING FACILITY: A facility that produces compost using some organic materials from a waste stream.

COMPOSTING PAD: An area within the composting site with a surface upon which the organic materials are processed.

CONTAMINANT: A substance capable of polluting a primary material by contact or mixture.

CUBIC YARD: The standard measure of waste volume, which roughly assuming an average rate of compaction.

CURING: The final stage of compost processing, after much of the readily metabolized material has been decomposed, in which the compost material further stabilizes.

DISEASE VECTOR: All insects, birds, rodents or other organisms capable of transmitting pathogens (disease causing organisms).

EPHEMERAL STREAMS: A stream that flows only in direct response to precipitation (rain, or melting snow and ice) in the immediate watershed and has a channel bottom that is always above the local water table.

EUTROPHICATION: The enrichment of nutrients in water leading to excessive algae or plant growth, followed by death, subsequent decomposition and depletion of oxygen in the water.

FRONT-END LOADER: A tractor or other vehicle with power-driven loading equipment at the front. This equipment is sometime referred to as a bucket loader.

GRINDER: A mechanical device used to breakup waste materials into smaller pieces. Grinding devices include hammermills, shears, drum pulverizers, wet pulpers and rasp mills.

GROUNDWATER: Water contained in the zone of perennial saturation (phreatic zone). It is differentiated from water held in the soil in chemical or electrostatic bonds in the perennially unsaturated zone.

HEAVY METALS: Metallic elements with atomic weights greater than sodium (23) such as lead, mercury, cadmium, and zinc that tend to be toxic to humans, plants, and animals at relatively low concentration and tend to bioaccumulate.

HOUSEHOLD SOLID WASTE: Solid waste, including garbage and trash generated by single and multiple family residences, hotels, motels, bunkhouses, ranger stations, crew quarters and recreational areas such as picnic areas, parks and campgrounds.

INDUSTRIAL SOLID WASTE: Solid waste generated by manufacturing or industrial processes that is not a hazardous waste or a special waste as designated by KRS 224.868, including, but not limited to, waste resulting from the following manufacturing processes: electric power generation; fertilizer or agricultural chemicals; food and related products or by-products; inorganic chemicals; iron and steel manufacturing; leather and leather products; nonferrous metals manufacturing/foundries; organic chemicals; plastics and resins manufacturing; pulp and paper industry; rubber and miscellaneous plastic products; stone, glass, clay, and concrete products; textile manufacturing; transportation equipment; and water treatment.

INORGANIC: Solid matter in which there are no carbon-to-carbon bonds, such as minerals, which will not undergo biological decomposition.

<u>LEACHATE</u>: Any liquid including suspended or dissolved components in the liquid that has percolated through or drained from waste.

<u>LEAVES</u>: Seasonal deposition from deciduous or coniferous trees, shrubs, bushes and other plants contained in yard waste.

<u>MUNICIPAL SOLID WASTE (MSW):</u> Garbage, refuse, trash and other solid waste from residential, commercial and community activities.

<u>NON-COMPOSTABLE</u>: Materials that will not decompose biologically or whose decomposition products are toxic.

<u>N:P:K RATIO</u>: Refers to the ratio of nitrogen to phosphorus to potassium in a compost product.

<u>ORGANIC WASTE</u>: Waste composed of materials which contain carbon-to-carbon bonds and are biodegradable, including paper, wood, food waste and yard waste.

<u>PATHOGENS</u>: Organisms capable of producing infection or disease often found in waste materials. The high temperature sustained in the composting process reduces pathogens.

<u>PERCOLATION</u>: Downward movement of water through the pores or spaces in rock and soils.

<u>pH</u>: The measure of how acidic (pH less than 7) or basic (pH above 7) a materials is. A pH of 7 is considered neutral.

<u>PUTRESCIBLE</u>: Susceptible to rapid decomposition by bacteria, fungi, or oxidation sufficient to cause nuisances such as odors, gases, or other offensive conditions.

<u>RESOURCE RECOVERY</u>: A term used to describe the extraction of economically useful materials and/or energy from solid waste. Often refers to the burning of waste for energy.

<u>RUN-OFF</u>: Any rainwater, leachate, or other liquid that drains overland or into the groundwater from any part of a facility.

<u>RUN-ON</u>: Any rainwater, leachate, or other liquid that drains onto any part of the facility.

SCREENING: The process of passing compost through a screen or sieve to remove large organic or inorganic materials and improve the consistency and quality of the end product.

SHREDDER: "See Grinder".

SOIL AMENDMENT/SOIL CONDITIONER: Means any substance which is intended to improve the physical characteristics of the soil, except commercial fertilizers, agricultural liming materials, unmanipulated animal manures, pesticides and other materials exempted by regulation.

SOLID WASTE: Any garbage, refuse, sludge, and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining (excluding coal mining waste, coal mining by-products, refuse and overburden), agricultural operations, and from community activities, but does not include those materials including, but not limited to sand, soil, rock, gravel, or bridge debris extracted as part of a public road construction project funded wholly or in part with state funds, recovered materials, special wastes as designated by KRS 224.868, solid or dissolved material in domestic sewage, manure, crops, or crop residue, or a combination thereof which are placed on the soil for return to the soil as fertilizers or soil conditioners, or solid or dissolved material in irrigation return flows or industrial discharges which are point sources subject to permits under Section 402 of the Federal Water Pollution Control Act, as amended (86 Stat. 880), or source, special nuclear, or by-product material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923).

SPECIAL WASTE: Those materials of high volume and low hazard which include but are not limited to mining waste, utility wastes (fly ash, bottom ash, scrubber sludge), sludge from water treatment facilities and wastewater treatment facilities, cement kiln dust, gas and oil drilling mud, and oil production brines. Other waste may be designated special waste by the cabinet.

STATIC PILE COMPOSTING: A method of composting in which oxygen and temperature levels are mechanically controlled by passive or forced aeration.

SUBSTRATE: The organic material, on which the decomposing microorganisms live and feed.

VOLUME REDUCTION: The processing of waste materials to decrease the amount of space they occupy. Compaction, shredding, composting and burning are all methods of volume reduction.

<u>WINDROW</u>: An elongated compost pile, usually about 6 to 12 feet high and up to hundreds of feet long.

<u>WINDROW COMPOSTING</u>: The composting of organic materials in a series of elongated piles. The windrows are turned periodically to aerate and mix the waste materials to speed up decomposition and reduce odor.

<u>YARD WASTE</u>: Debris such as grass clippings, leaves, garden waste, brush and trees.